SCIENCE

DECEMBER 15, 1950

INSTRUMENTATION PROBLEMS IN PHYSIOLOGICAL RESEARCH
EARL H. WOOD

TECHNICAL PAPERS

COMMENTS AND COMMUNICATIONS

BOOK REVIEWS

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NEWS AND NOTES

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VOLUME 112, NUMBER 2920

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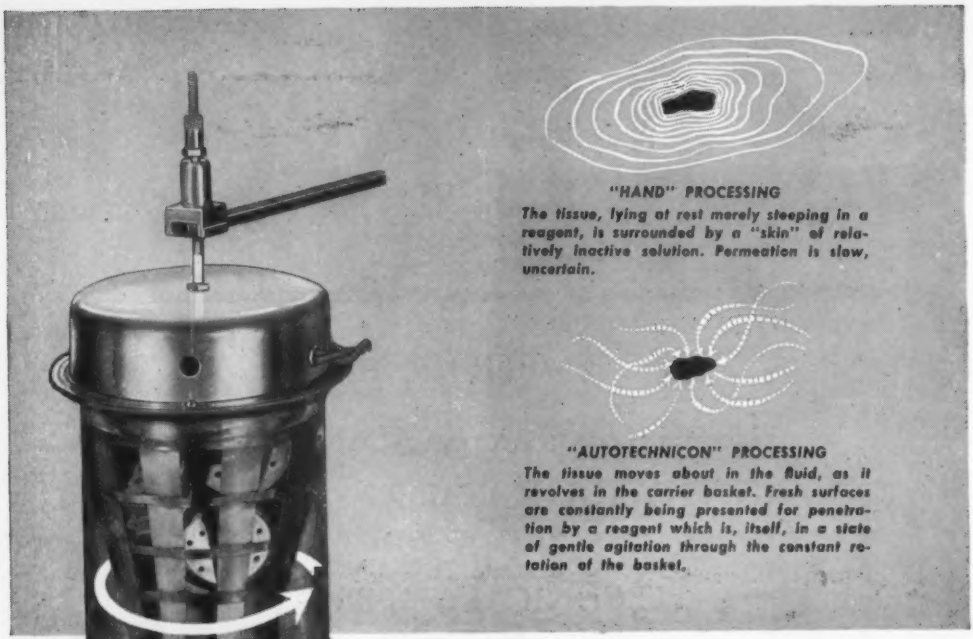

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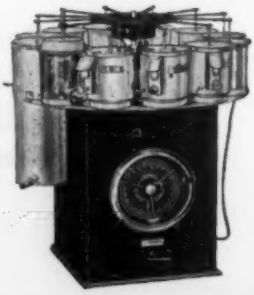

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What GENERAL ELECTRIC People Are Saying

T. M. BERRY

General Engineering & Consulting Laboratory

CONTOUR FOLLOWER: The optical contour-follower control is an automatic curve-following device. It has several unique features which make it ideally suited for use as a machine-tool control for the purpose of reproducing, in metal, a shape designated on a line drawing.

A number of machine-tool controls of the template-follower type are in general use for machining duplicates from a metal master pattern. The optical contour follower is used in making the master pattern itself.

In many cases thousands of duplicates are made from a single metal master, and only a few masters are required. The amount of time and labor involved in making these few accurate masters is relatively unimportant. Developmental manufacturing, however, requires that a master be duplicated only a relatively few times and that a much larger number of masters be made. In this case the time and labor involved in making a master are very important. It was for the purpose of reducing this time and labor that the optical contour follower was developed. . .

"G.E. Review"
June, 1950.

★

J. P. DITCHMAN

Lamp Department

PLANT LIGHT: The advent of new artificial light sources stimulates the efforts of plant physiologists and other scientists to solve the fundamental riddle of how plants grow. Carbon arc incandescent lamps, sodium lamps, mercury lamps, and many combinations of these have been used in growth chambers where light, humidity, temperature, and air are controlled to grow plants entirely under artificial conditions. Today laboratories are being equipped with combinations of fluorescent and incandescent lamps for this purpose. . .

There are many laboratories in agricultural colleges, equipped with rooms for growing plants entirely under artificial conditions, trying to develop methods independent of natural conditions. These research objectives, it is said, could lead (if successful) to political and economic consequences which could rival those of the atomic bomb. If we could maintain food production under ground, we could provide a hedge against some of the spectacular devastation feared in an atomic war.

Illuminating Engineering Society
Pasadena, California
August 21, 1950

★

H. A. LIEBHAFSKY
A. E. NEWKIRK

Research Laboratory

CORROSION STUDIES: The annual cost of corrosion is so great that it is desirable to explore every promising technique for the investigation of corrosion processes. Among the most feared of these processes is pitting, which, being a form of localized attack, is well suited to investigation by methods such as radiography that depend upon the absorption of x rays.

To illustrate the value of these methods, the pitting of three kinds of stainless steel in ferric chloride solution at room temperature has been studied. Radiographs have been obtained that show how pitting varies with the kind of steel and with the degree of cold deformation. Furthermore, it has been possible to demonstrate that the direction of attack can be profoundly influenced by gravitational forces and by the occurrence of crevices. While the radiographs largely confirm past experience, they provide much detailed evidence that might escape visual observation . . .

Finally, it has been possible to measure the rate of pit growth on specimens continuously immersed—an important fact, because removal of the specimen from ferric chloride solution can stop altogether the growth of particular pits. The technique employed could be used to measure in favorable cases the rate of pitting in closed systems.

National Academy of Sciences
Schenectady, New York
October 10, 1950

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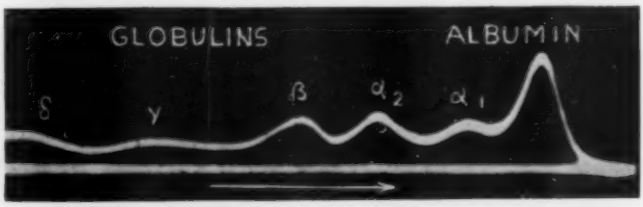

WRITE FOR BULLETIN 2281-K

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Special Instrumentation Problems Encountered in Physiological Research Concerning the Heart and Circulation in Man[1]

Earl H. Wood

Section on Physiology, Mayo Foundation, University of Minnesota, and *Mayo Clinic, Rochester*

THE FUNCTION OF THE HEART is to maintain an adequate flow of blood through the lungs and to the body. A quantitative study of this function therefore requires physical measurements of such variables as pressure, volume, velocity of flow, volume of flow, and others. For the most part, measurement of physiologic variables concerned in the heart and circulation of man requires that these determinations be carried out on intact unanesthetized human beings. Therefore, direct measurements of many of the variables must commonly be made through small needles or long, narrow-bore, flexible tubes. Since variables such as blood pressure have both static and dynamic components, their high-fidelity recording under such circumstances requires close attention to the frequency and damping characteristics of the instruments used. Adequate instrumentation must be capable of faithful reproduction of both the static component and all dynamic components of a magnitude to be of practical importance.

The highest frequencies of the dynamic components of practically important magnitudes in a complex wave form, such as an arterial pressure pulse or the action potential complex of the heart muscle (electrocardiogram), are not accurately known. It is generally considered, however, that instruments with a uniform dynamic sensitivity to the tenth harmonic of the fundamental frequency of such complex wave forms are suitable for high-fidelity recording of the wave concerned. By this criterion, since the heart rate of human beings seldom exceeds 240 beats per minute, an instrument with a uniform sensitivity from 0 to 40 cycles per second should be adequate for the recording of arterial blood pressure and most other physiologic variables associated with the cardiovascular system. Recent direct evidence (*22*) indicates that manometer systems with a uniform dynamic response to 10 cycles per second will record peripheral arterial pressure in man without significant amplitude distortion. It is of interest also that the sensitivity of the majority of clinically acceptable electrocardiographs is diminished by more than 20 per cent at a frequency of 40 cycles per second.

In the functioning cardiovascular system, the various factors of pressure, flow, velocity, rate, and so forth are all mutually interrelated and continuously varying. Therefore, accurate studies of the over-all function of the circulatory system require continuous recording of multiple variables.

The desirability of recording multiple physiologic variables in studies of cardiovascular function is well illustrated by the results of studies concerning the nature of the blackout and unconsciousness sometimes experienced by pilots as a result of exposure to positive acceleration or centrifugal force (*12, 16, 26*). Sudden exposure of a fighter pilot to a commonly experienced positive acceleration of five times the force of gravity ($5g$) will, because of the effective increase in the weight of the blood, reduce arterial pressure at head level to zero. Studies of the physiologic effects of this type of stress in human beings are carried out under controlled laboratory conditions by means of human centrifuges (*26*), perhaps the largest type of physiologic instrument designed for the study of the circulation (*1*) (Fig. 1). Physiologic recordings taken during exposure of a normal subject to positive acceleration on the human centrifuge are shown in Fig. 2. The left panel shows the changes produced by an exposure to $4.6g$ when the subject was unprotected. The increase in weight of the blood associated with this acceleration reduced arterial blood pressure temporarily to zero at head level, and a temporary loss of vision resulted. The reflex compensatory increases in blood pressure at heart level induced by the lowered blood pressure in the head region (carotid sinus) are evident during the latter portion of this exposure. The center panel illustrates the increase in arterial pressure produced by inflation of a pneumatic antiblackout suit. The panel on the right was recorded from the same subject during exposure to $5.5g$ while protected by the antiblackout suit. Protection is afforded by the increase in blood pressure at heart level produced by inflation of the suit.

[1] Abstract of paper presented at Gordon Research Conference on Instrumentation, August 4, 1950.

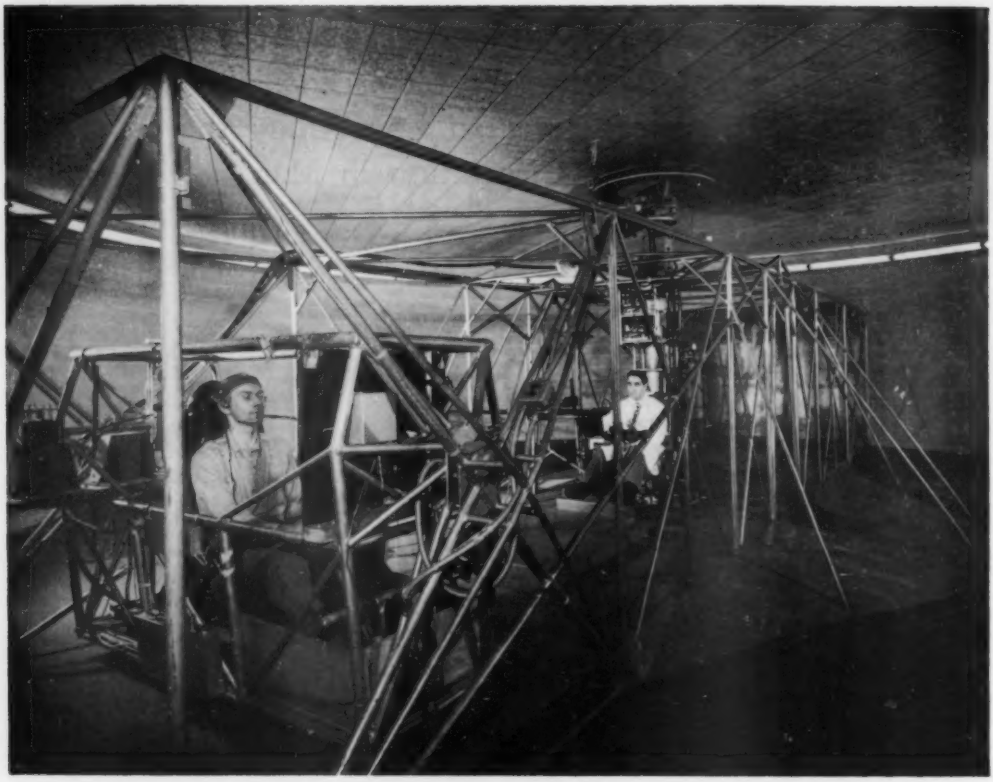

FIG. 1. Human centrifuge, designed to simulate the positive acceleration encountered in aircraft during combat or aerobatic maneuvers. This centrifuge (*1*), which is a rectangular steel frame 37 ft in length, rotates in a circular room 40 ft in diameter. The subject (left) sits in a cockpit suspended so as to be free to swing radially. The observer, sitting near the center of rotation, controls the start and the stop of the centrifuge, and tests the reactions of the subject to visual and auditory signals during each exposure.

The type and use of instrumentation for cardiovascular research are well illustrated by the technique of cardiac catheterization (*2, 20*). This procedure involves the passage of a plastic catheter, 100–120 cm in length and approximately 0.25 cm in diameter, from a peripheral vein into the great vessels and chambers of the heart. Analyses of roentgenograms, pressure tracings, and blood samples obtained from various positions in the circulatory system provide data that have proved to be of value diagnostically and for the solution of special problems concerning the physiology of the circulation and respiration in man. An assembly set up for this procedure is shown in Fig. 3. The electrical variations of the various pickup units are recorded continuously on photokymographic cameras located in an adjacent recording room. For certain of the phenomena encountered in this and other procedures it is advantageous for purposes of later analysis to record the variations at two different chart speeds. This is accomplished by simultaneous recordings on two kymographic cameras run at the different chart speeds desired (Fig. 4).

In the cardiac catheterization technique, the actual procedure is determined to a large extent by the results of measurements being made through the catheter (particularly the pressures and blood oxygen saturations) at the time. It is therefore important to have accurate means of visually monitoring the variations while they are being continuously recorded. This can be accomplished by arranging a mirror assembly so as to reflect a small portion of the galvanometer beams back to appropriately located visual scales (Fig. 5).

Examples of the physiologic recordings obtained with the oscillographic assembly are shown in Figs. 6 and 7. The individual instruments used to record the multiple variables illustrated were especially adapted commercially available devices or, for the most part,

were designed and developed specifically for the purposes of this particular application.

The discussion of these individual devices will be confined to the instruments concerned with direct measurements of the pressure and photometric measurement of percentage oxygen saturation of blood in the circulatory system of man.

Measurement of Blood Pressure

The pressures encountered in the circulation will, in nearly all instances, fall within a range from approxi-

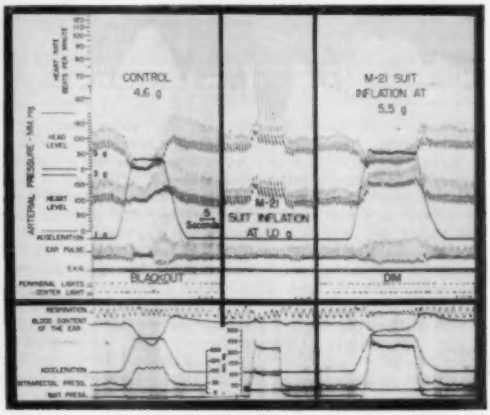

Fig. 2. Physiologic recordings taken from a normal subject during exposure on the human centrifuge to a positive acceleration of 4.6*g* without protection (left panel) and to 5.5*g* when protected by a pneumatic antiblackout suit (right panel). Black dashes show the subject's reaction times to peripheral and central light signals. Heart rate was recorded by means of an instantaneous cardiotachometer (*19*). Pressures were recorded with strain gauge manometers (*13*). Ear pulse and ear opacity were recorded with a photoelectric earpiece (*25*). Respiration was recorded by a thermocouple mounted in a mouthpiece through which the subject breathed. The upper trace marked *acceleration* is a tachometer record of the rpm of the centrifuge. The lower trace marked *acceleration* was recorded by means of a strain gauge accelerometer (Statham) mounted in the centrifuge cockpit.

mately 300 mm of mercury above to a few millimeters of mercury below ambient barometric pressure. The dynamic components of the pressure variations encountered will, for the most part, be encompassed by a frequency range of 0–50 cycles per second. For practical purposes this frequency range may be even more limited (*6, 22*). The sensitivity required varies from approximately 1 mm up to several centimeters deflection per millimeter of mercury pressure.

A manometer system suitable for direct recording of blood pressure should possess the following characteristics (*9*): high natural frequency; high stability; linear calibration; usability with long leads; insensitivity to movement, temperature, humidity, and acceleration; imperviousness to electrolyte solutions; simplicity of operation; and construction for ease of sterilization and removal of air bubbles entrapped in the hydraulic system.

Fig. 3. Assembly of apparatus for diagnostic cardiac catheterization procedure. Subject is lying on x-ray table, and movable roentgenoscopic screen and x-ray plate holder for visualization of radiopaque catheter are in position over chest. Earpiece attached to right ear provides a continuous record of the percentage oxygen saturation of subject's arterial blood (*23*). Device extending into the nostrils and over the mouth contains 3 thermocouples, which give a qualitative record of the respiration. Continuous recordings of the electrocardiograph and heart rate are picked up from the electrocardiographic leads applied to the chest. Cardiac catheter, in place in the antecubital vein, is connected by means of a three-way stopcock to: (1) a pressurized wash bottle containing a sterile heparinized saline solution, (2) a strain gauge manometer (*13*) for continuous recording of pressures transmitted through the catheter, and (3) a cuvette oximeter for whole blood (*8, 21*) to determine the oxygen saturation of blood samples drawn through the cardiac catheter. The electrical variations from these various pickup units are recorded continuously on a kymographic camera located in an adjacent recording room.

An ideal blood pressure manometer has as yet not

Fig. 4. Photokymographic cameras used for simultaneous recording of multiple physiologic variables concerned with the heart and circulation. Camera on the right (for 18-in. width photographic paper) is run continuously at a slow chart speed (1.25 or 5 mm/sec) throughout the procedure. The camera, mounted face up directly below the front-surfaced mirror, is set for a chart speed of 29 mm/sec and adjusted in relation to the mirror so as to photograph the lower portion of the same galvanometer beams focused on the upright camera. This fast camera is run only occasionally during the procedure, at points at which study of the contours of the recorded variations might prove of value.

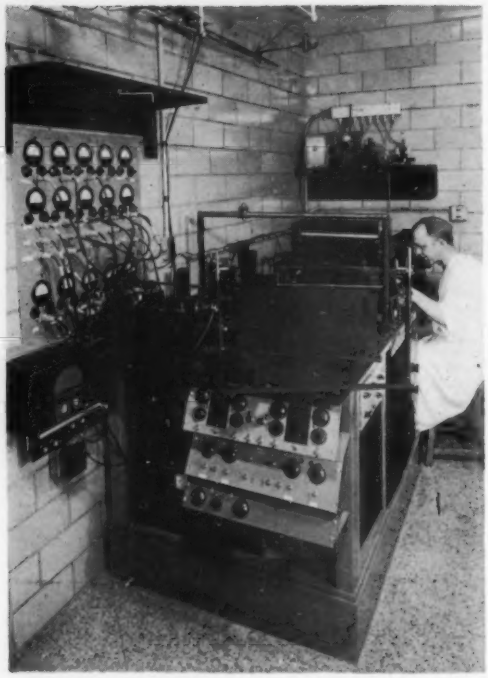

FIG. 5. Oscillographic recording assembly used for cardiac catheterization and other procedures. The various electrical leads coming from the subject terminate in the junction panel in left foreground. Twenty or more galvanometer traces can be recorded simultaneously on the photokymographic camera shown in background beside camera operator. High-sensitivity galvanometers used, with an optical arm of 4 m, for recording oximeter tracings, etc., are mounted above camera (upper background). Images from their mirrors are reflected back to the kymographic camera by means of a large front-surface mirror mounted on the oscillographic table (back of mirror visible in foreground). Lower portions of these beams are reflected by another mirror (face visible at midportion of table) to a visual scale (not shown) mounted over foreground control panel so that an operator can monitor the tracings and relay the results via a speaker system (lower left) to the adjacent room while the traces are being continuously recorded. In these types of studies a high degree of d.c. stability is required over long periods of time; therefore the use of vacuum tube amplification is avoided if possible, the electrical variations from the pickup units being recorded directly, whenever feasible, by means of high-performance galvanometers.

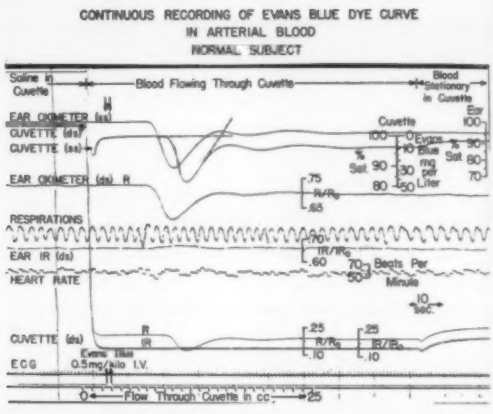

FIG. 6. Continuous recording of dye concentration in arterial blood after nearly instantaneous injection of 40 mg of Evans blue dye into left antecubital vein of a normal subject. Dye concentration was recorded by means of ear oximeter attached to left ear and cuvette oximeter attached to an indwelling needle in the radial artery. The subject was breathing 100% oxygen, so that constant and complete saturation of the arterial blood with oxygen was assured. Simultaneous single-scale and double-scale operation of the cuvette and earpiece were used (Fig. 16). Galvanometer traces labeled *ss* (single-scale) are recordings of the difference in output of the red-sensitive and infrared-sensitive photocells of ear and curvette oximeters, respectively. Galvanometer traces labeled *ds* (double-scale) are individual recordings of the output of the red-sensitive and infrared-sensitive photocells of earpiece and cuvette. R/R_0 indicates the ratio of red light transmitted through the blood-containing ear or blood-filled cuvette to the light transmitted through the bloodless (pressurized) ear or saline-filled cuvette. IR/IR_0 is the similar ratio for near infrared light transmission through the ear or cuvette. Respirations were recorded by monitoring the pressure variations in the oxygen mask, using a sensitive strain gauge (± 10 mm of mercury range). Heart rate was recorded by means of an instantaneous cardiotachometer (*19*). The subject's cardiac output, blood volume, and circulation time from arm to ear can be calculated from the time-concentration curve of the dye in arterial blood (*18*).

been developed. In my opinion, the strain gauge pressure transducers of the unbonded type, which have been adapted for blood pressure recording (*17*) (Fig. 8), more nearly approach fulfillment of the foregoing requirements than any of the other commercially available manometers.

Under practical conditions of use, the dynamic response of hypodermic needle or catheter manometer systems is subject to large variations that are due to the marked effect of even minute air bubbles entrapped in the connections of the hydraulic system between the gauge and the needle or catheter (*14*). Because of this fact it is important to have convenient methods of checking the dynamic response of manometer systems at the time of their use. This can be done by recording the response of the system to a square wave pressure change (Fig. 9) or to sine wave pressure variations of variable frequency generated by means of hydraulic pressure oscillators especially designed for this purpose (*9, 11, 14*) (Fig. 10). The alteration of the dynamic response characteristics of a strain gauge manometer as it is assembled into a multipurpose hypodermic manometer system (*7*) is illustrated in Fig. 11.

In the procedure of cardiac catheterization it has been found that, even when catheter manometer systems of satisfactory dynamic response are used, the pressure recordings obtained from the pulmonary artery and right ventricle are badly distorted by arti-

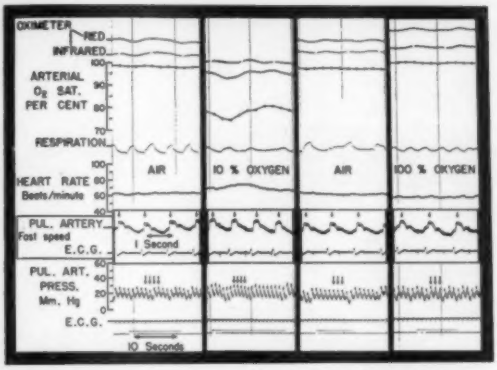

FIG. 7. Recordings from a human being during inhalation of air, 10% oxygen, and 100% oxygen. Pressure in pulmonary artery was recorded by means of miniature pressure pickup unit attached to intracardiac end of cardiac catheter (*6*). Inserts showing contours of the pressure pulse waves and of the electrocardiogram are from simultaneous records photographed at a faster chart speed (29 mm/sec). Arrows indicate identical pulses on the fast- and slow-speed recordings. Differences in contour of the pulse wave and slight differences in pressures are evident during the periods of breathing the different gas mixtures.

facts. These artifacts are due to the pressures generated within the catheter from the accelerations and decelerations of the fluid column in the lumen. They are associated with the movements of the catheter usually introduced by the heartbeat (*6, 14*). This difficulty can be eliminated by mounting a miniature manometer on the intracardiac end of the catheter (*6*). The mass (approximately 15 mg) of the movable elements in the (2.5 mm × 12 mm) variable reluctance manometer (*7*) that has been used is so small

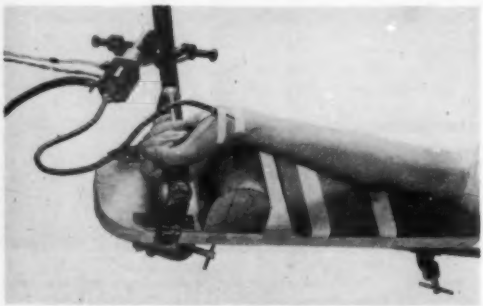

FIG. 8. Hypodermic strain gauge manometer assembly used for recording arterial pressure in the human centrifuge (*15*) (Fig. 2). Manometer is connected via lead tubing to an indwelling needle in the radial artery. The 2 pairs of electrical leads connect to a d.c. source for maintaining a constant voltage across the strain gauge Wheatstone bridge circuit and to an oscillographic galvanometer, which records the output of the strain gauge. Rubber tubing is connected to a pressure bottle filled with sterile saline solution containing an anticoagulant (heparin) for intermittent flushing of the manometer system to prevent formation of blood clots in the needle.

that the reactive forces resulting from the accelerations produced by the heartbeat do not produce appreciable pressure artifacts (*4, 5*) (Figs. 7, 12). Use of this type of manometer requires d.c. vacuum tube amplification (approximately 150,000:1), with strict limitations concerning the allowable amount of base line and sensitivity drift. Carrier wave type amplifiers have been used with reasonable success.

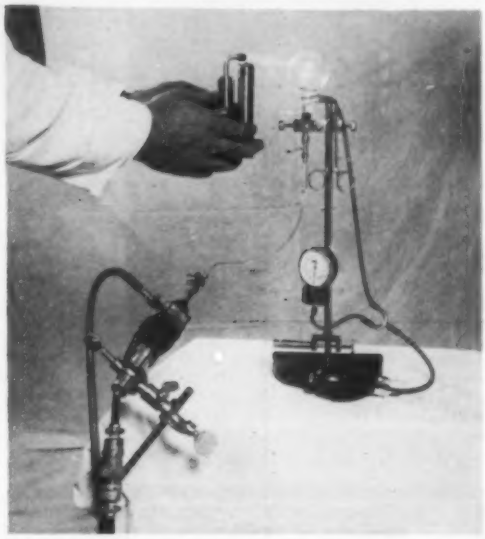

FIG. 9. Apparatus for testing the dynamic response of manometer systems by subjecting them to a square wave pressure change. The needle of the manometer assembly is inserted into the fluid contained in the pressure chamber. The pressure in the air space over the fluid is increased by means of the hand bulb to just under the bursting pressure of the finger cot covering the pressure chamber. Balloon is then exploded with a blow torch, thus producing practically an instantaneous decrease to ambient pressure.

PHOTOMETRIC MEASUREMENT OF BLOOD OXYGEN SATURATION

One of the chief functions of the circulation is to transport oxygen in the form of oxyhemoglobin from the lungs to the tissues. Measurement of the percentage oxygen saturation of the hemoglobin contained in blood is therefore important in studies of cardiovascular function. Since the blood oxygen saturation is mutually interrelated with other physiologic variables and may under certain circumstances be continuously varying, methods of measurement that allow continuous recording are desirable. Photoelectric devices, commonly called oximeters, have been developed for this purpose.

The differences in light absorption of oxyhemoglobin and reduced hemoglobin in the visible and infrared regions of the spectrum constitute the most convenient basis on which to carry out continuous photometric

FIG. 10. Electromagnetic hydraulic transducer for studying response characteristics of manometer systems to square wave and sine wave pressure variations (*11*). Needle of the manometer assembly being tested (upper right) is inserted into a water-filled lucite chamber. Standard electronic oscillator actuates an electromagnetic drive unit coupled through a metal membrane to the lucite chamber, thus translating the sine wave oscillator current into sine wave pressure variations in the chamber. The generated pressure variations are monitored by means of an unbonded strain gauge unit coupled to the opposite end of the pressure chamber through a similar metal membrane. Constant pressure amplitude at varying frequencies is achieved by maintaining constant current (monitored by the milliammeter) to the drive unit. Square wave pressure variations are produced by making and breaking a d.c. source (B battery) to the electromagnetic driver.

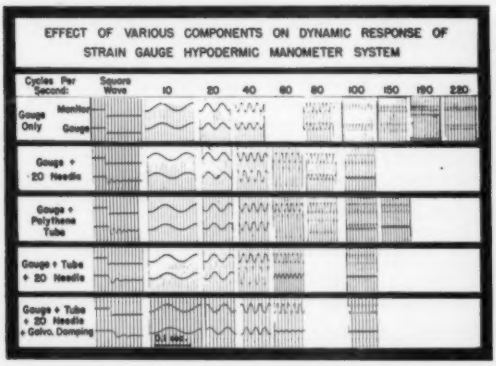

FIG. 11. Alteration of dynamic response of a strain gauge manometer (Statham gauge, range ±760 mm of mercury) produced by the hydraulic connections required to convert it to a multipurpose hypodermic manometer (*24*). Top tracing in each panel is the recording from the gauge monitoring the pressure chamber; and bottom tracing is the recording from the manometer system being tested. The 20-gauge hypodermic needle was 5 cm in length and 0.056 cm internal diameter. The polythene tubing assembly consisted of a glass hypodermic adapter for attachment to the needle, a 26-cm length of polythene tubing (2.1 I.D., 3.4 mm O.D.), and a two-way hypodermic stopcock to permit blood sampling and connection to the manometer proper. Galvanometer damping (lower panel) consisted of the use of a galvanometer with a resonant frequency of 40 c/sec, utilizing an external damping resistance of 70 ohms (optimal damping resistance: 250 ohms).

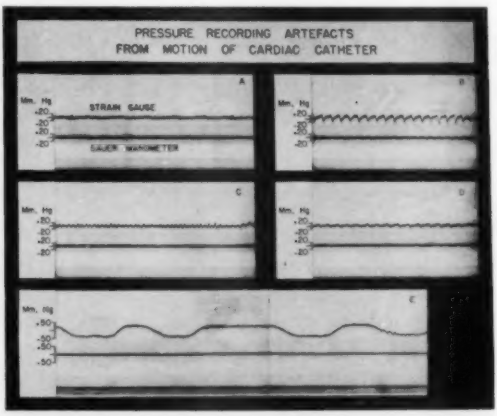

FIG. 12. Pressures generated by simultaneous identical motions of intracardiac ends of two 8 F cardiac catheters, one with a Gauer-Glenapp manometer attached to the intracardiac tip, and the other filled with fluid and with the external end attached to a strain gauge manometer, this overall system being optimally damped. *A*, vertical circular motion of tips of both catheters through a diameter of 10 cm at rate of 1 c/sec; *B*, pendular motion along axis of catheter approximately 4 cm in amplitude at rate of 2 c/sec; *C*, pendular motion transverse to axis of catheter through a distance of 4 cm at rate of 2 c/sec; *D*, catheter tip fixed and oscillatory motion imparted to the shaft of the catheter; *E*, catheter tip rotated through arc of 180° on a radius of 50 cm.

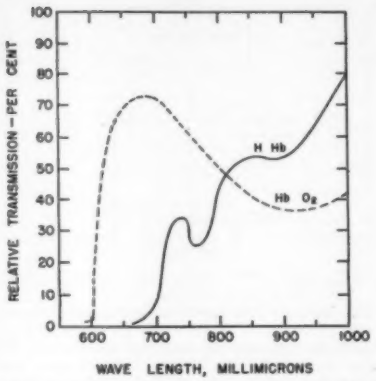

FIG. 13. Relative spectral transmission of reduced and oxygenated hemoglobin solutions (calculated from Horecker's data [*10*]).

measurements of the oxygen saturation of circulating whole blood. These differences are illustrated in Fig. 13. Under the conditions of these measurements, the oxyhemoglobin solutions transmitted approximately 70 per cent of the incident red light of a wavelength of approximately 640 mμ, whereas reduced hemoglobin absorbed practically all the light of this wavelength. At approximately 800 mμ, however, in the near infrared, the relative transmission of oxyhemoglobin and reduced hemoglobin was identical. Therefore, the transmission of light of a wavelength of 800 mμ is dependent on the *hemoglobin content* of the transilluminated solutions, whereas the transmission of light of a wavelength of 640 mμ is a function of the *percentage saturation* of this hemoglobin with oxygen. The ratio of the transmission of visible red and near infrared light can be used, therefore, to determine the percentage oxygen saturation of the hemoglobin contained in the transilluminated solutions.

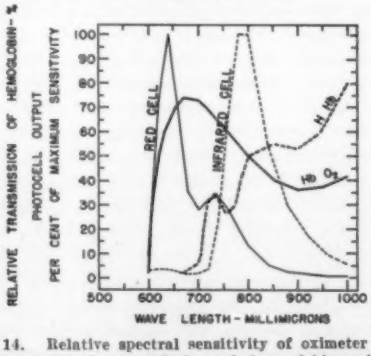

FIG. 14. Relative spectral sensitivity of oximeter photocells and spectral transmission of hemoglobin solutions. Note that maximal sensitivity of the red cell is in the spectral region of maximal difference between oxygenated and reduced hemoglobin, whereas sensitivity of the infrared cell is at a crossover, or isobestic, point of these 2 pigments.

The spectral sensitivity of the iron-selenium photocell filter combinations contained in the oximeter earpiece and the cuvette oximeter for whole blood is illustrated in Fig. 14. The maximal sensitivity of the red photocell is at 640 mμ, at which point the light transmission of oxyhemoglobin and reduced hemoglobin is maximally different. The peak sensitivity of the infrared cell is at approximately 800 mμ, at which point the light transmission of oxyhemoglobin and reduced hemoglobin is practically identical.

The cuvette oximeter for whole blood (*21*) (Fig. 3) is used for photometric determinations made directly on blood flowing or stationary in the cuvette tubing. The oximeter earpiece (*23*) can be used for similar determinations on the blood circulating in the intact ear (Fig. 15).

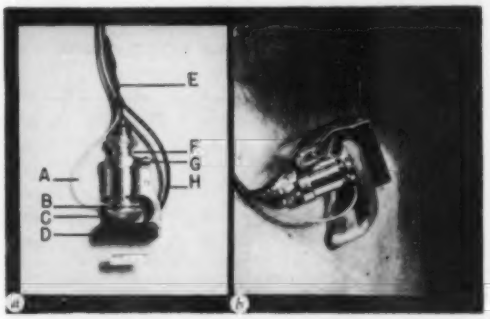

FIG. 15. Earpiece for the oximeter (*3, 23*): *A*, polythene tubing leading into *B*, pressure chamber; *C*, rubber diaphragm of pressure capsule (inflated to 20 mm of mercury); inflation of this pressure capsule to 200 mm of mercury renders portion of the ear in the optical pathway of earpiece practically bloodless; *D*, housing for photoelectric cells; *E*, lead wires; *F*, housing for light source; *G*, set screws for fixing position of pressure capsule; *H*, strain relief and ground wire. *b*: Oximeter earpiece in place on ear.

Two methods (double-scale and single-scale) of operation of these devices have been used. The double-scale method is the more accurate but is also the more time-consuming of the two techniques. The outputs of the red and infrared cells are recorded separately. The optical density of the blood contained in the cuvette or the ear is determined by measuring first the light transmission of the bloodless (pressurized) ear or cuvette (filled with saline solution) and then the transmission with the ear or cuvette filled with blood. The logarithm of the ratio of light transmission without blood to light transmission with blood is a function of the optical density of the blood interposed in the optical pathway of these devices. The ratio of the optical density of blood in the visible red to the optical density in the near infrared is a function of the percentage saturation of the blood hemoglobin with oxygen.

The single-scale method of operation utilizes only one galvanometer, is simple in technique, and the facility of a direct reading of the percentage oxygen saturation renders it preferable to double-scale operation in applications in which the greater variability of the results obtained does not constitute a serious objection. The circuit used measures the difference in output of the red and infrared photocells. The output of the infrared cell is set to an arbitrary negative galvanometer deflection with blood in the optical pathway of the instrument. (This "infrared setting" determines the final sensitivity of the devices to changes in oxygen saturation.) The blood is then removed from the optical pathway of the instrument, and the output of the red cell is adjusted to be equal and opposite to that of the infrared cell (galvanometer deflection: zero). The galvanometer deflections then obtained when blood is allowed to reenter the instrument are a function of the percentage oxygen saturation of the blood.

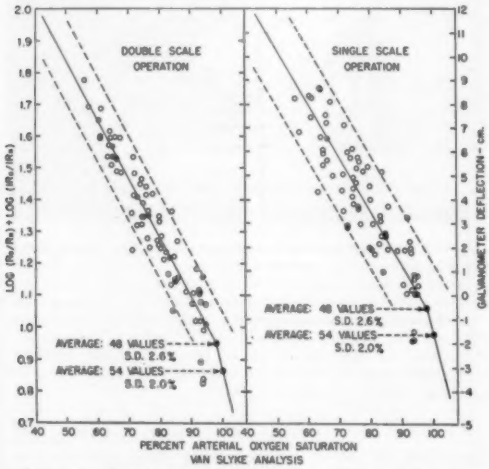

FIG. 16. Empirical calibration curve of an oximeter earpiece for determining arterial oxygen saturation in man. Simultaneous single- and double-scale operations were used, based on 177 simultaneous photoelectric and Van Slyke determinations of arterial oxygen saturation in man. The dashed lines delineate the areas representing twice the standard duration of single photometric analyses in the saturation range below 95 per cent.

Although these instruments can be used for direct measurement of blood oxygen saturation, an initial empirical calibration against manometric determinations of blood oxygen saturation is necessary, irrespective of whether the double-scale or single-scale method of operation is used (Fig. 16). In certain applications, such as the cardiac catheterization procedure, in which it is advantageous to obtain an immediate reading of blood oxygen saturation, as well as an accurate recording for later analysis, a circuit that

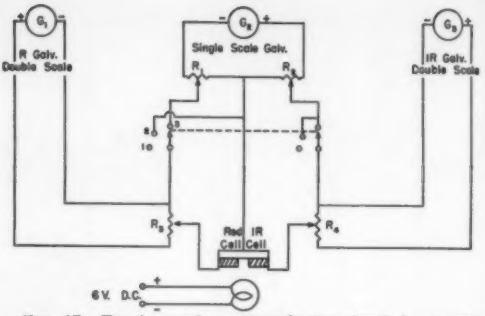

FIG. 17. Earpiece and cuvette oximeter circuit incorporating simultaneous double- and single-scale operation. R_1 and R_2, single-scale potentiometer controls for red and infrared cells, respectively; G_2, single-scale galvanometer ($R_1 + R_2$ = optimal damping resistance); R_3 and R_4, double-scale potentiometer controls for red and infrared cells, respectively; G_1, red cell galvanometer for double-scale operation (R_3 = optimal damping resistance); G_3, infrared cell galvanometer for double-scale operation (R_4 = optimal damping resistance); 1, control switch position for reading galvanometer zeros; 2, control switch position for adjusting sensitivity of infrared cell for single-scale operation (earpiece on flushed ear or blood in cuvette oximeter); 3, control switch position for adjusting sensitivity of red cell for single-scale operation (earpiece on bloodless [pressurized] ear or saline solution in cuvette oximeter). After adjustments 2 and 3 are completed, the deflections of the single-scale galvanometer produced in switch position 3 are a function of blood oxygen saturation in flushed ear or cuvette oximeter.

provides simultaneous single- and double-scale operation has been used (Fig. 17). The single-scale readings are then read visually, and the double-scale galvanometer deflections are recorded for later more accurate analysis. Calibration data obtained with an oximeter earpiece using this simultaneous single- and double-scale method of operation are illustrated in Fig. 16.

In summary, because of the dynamic character and interrelations of the physiologic variables concerned in the cardiovascular system, study of the functions of this system in the intact animal requires instrumentation capable of continuous recording of the static and dynamic components of the multiple physiologic factors involved. Reasonably satisfactory instrumentation is available for continuous recording of the electrocardiogram, heart rate, respiration, temperature, blood pressure, blood oxygen saturation, and other factors. Development is still lacking, however, in instruments capable of high-fidelity recording of many other variables of importance to the cardiorespiratory system. The perfection of such devices capable of continuously recording in the intact animal such variables as, for example, blood oxygen and carbon-dioxide tension, the cardiac output, regional blood flow, the gas composition of the breath during each respiratory cycle, and so on, would greatly facilitate studies concerned with further elucidation of the physiology of the heart and circulation in man.

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Technical Papers

Description of the Chemostat

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We have developed a device for keeping a bacterial population growing at a reduced rate over an indefinite period of time. In this device, which we shall refer to as the Chemostat, we have a vessel (which we shall call the growth tube) containing V ml of a suspension of bacteria. A steady stream of nutrient flows from a storage tank at the rate of w ml/sec into the tube. The contents of the tube are stirred by bubbling air through it, and the bacteria are kept homogeneously dispersed throughout the tube at all times. An overflow sets the level of the liquid in the growth tube, and through that overflow the bacterial suspension leaves the tube at the same rate at which fresh nutrient enters it.

The chemical composition of the nutrient is such that it contains a high concentration of all growth factors required by the bacterium, with the exception of one, the controlling growth factor, the concentration of which is kept relatively low. The concentration of the controlling growth factor, a, in the storage tank will then determine the density, n, of the bacterial population in the growth tube in the stationary state, and it can be shown that, except for very low values of n, we have $n=\frac{a}{A}$, where A is the amount of the controlling growth factor needed for the production of one bacterium.

The growth rate $\alpha=\frac{1}{n}\frac{dn}{dt}$ of a strain of bacteria is a function of the concentration, c, of the controlling growth factor in the medium, and in general we may expect the growth rate, at low concentrations c, first to increase rapidly with increasing concentration and then slowly to approach its highest attainable value, α_{max}.

The Chemostat must be so operated that the washing-out time, $\frac{V}{w}$, should be lower than the growth rate α_{max} for high concentrations of the controlling growth factor. It can be shown that in that case a stationary state will become established in which the growth rate, α, will be just equal to the washing-out rate, $\frac{w}{V}$.

What happens is that n will increase until it becomes so large that the bacteria will take up the controlling growth factor from the tube just as fast as it is necessary in order to reduce c to the point where the growth rate $\alpha(c)$ becomes equal to the washing-out rate, $\frac{w}{V}$.

Using a tryptophane-requiring strain of coli and a simple lactate medium with tryptophane added, we have used both lactate and tryptophane as the controlling growth factor. Using tryptophane, we have kept bacterial populations growing over long periods of time at rates up to ten times lower than normal. We are thus able to force protein synthesis to proceed very slowly while certain other biochemical processes may continue at an undiminished rate.

A study of this slow-growth phase by means of the Chemostat promises to yield information of some value on metabolism, regulatory processes, adaptations, and mutations of microorganisms. A study of the spontaneous mutations of bacteria growing in the Chemostat has been made and is being published elsewhere.

Because for most investigations a number of such Chemostats will be needed, we attempted to perfect a simple yet adequate design. Of various possible designs, we eliminated those in which changes in the barometric pressure affect the rate of flow of the nutrient from the storage tank into the growth tube. We also discarded designs that permit growth of the bacteria on the inner walls of the growth tube, or permit growth of bacteria in the Chemostat anywhere except homogeneously dispersed in the liquid nutrient in the tube. After trying out several designs, we found the one shown in Fig. 1 satisfactory.

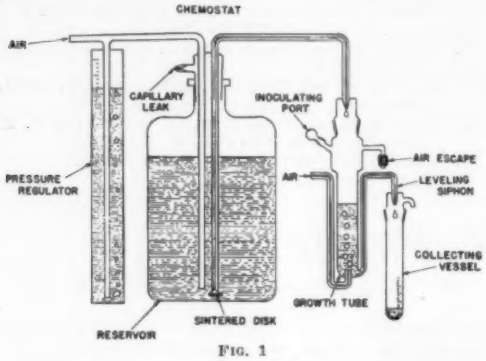

FIG. 1

A tube leading to the bottom of the storage tank is connected to a small air compressor (for example, an air pump such as is used for aerating aquaria). When the compressor is first started, the air rises rapidly in bubbles through the nutrient liquid in the storage tank and accumulates in the space above the liquid level until the pressure in the nutrient at the bottom of the tank becomes equal to the air pressure in the tube. The air space in the storage tank above the liquid level communicates through a narrow capillary with the outside air, and therefore the air will continue indefinitely to bubble through the nutrient liquid in the storage tank, but at a very slow rate (of perhaps one bubble per minute).

The pressure of the air entering the tube is regulated by a simple pressure regulator consisting of an air outlet located at the bottom of a glass cylinder filled with water up to a certain level. Above this level, the air communicates freely with the outside air. By changing the water level in the pressure regulator, the air pressure can be adjusted to any value required for the operation of the Chemostat.

In this arrangement, the pressure at the bottom of the storage tank will always be greater than the pressure of the outside air by the height of the water column in the pressure regulator, and hence will be independent of the height of the level of the nutrient liquid. This is important because the level of the nutrient will gradually fall during the operation of the Chemostat.

From the storage tank the nutrient liquid is forced through a sintered glass filter into the growth tube, where it is mixed drop by drop with the bacterial suspension. The content of the growth tube is continuously stirred by aeration.

The level of the liquid in the tube is set by a siphon, and the volume of the bacterial suspension is thus maintained constant. The nutrient liquid and the bacteria suspended in it leave the tube through the syphon at the same rate at which fresh nutrient enters. The air space above the nutrient liquid in the growth tube communicates with the outside air, hence the pressure which forces the nutrient liquid through the sintered disk is at all times equal to the height of the water column in the pressure regulator.

If, after the Chemostat has been in operation for some time, the barometric pressure falls very suddenly, the pressure of the air entering into the storage tank also falls suddenly, and the nutrient liquid will rise in the air pressure tube to a certain height. If this happens, the pressure at the bottom of the storage tank will no longer exceed the outside pressure by the height of the water column in the regulator, but rather by a greater amount, and the flow of the nutrient liquid into the growth tube increases. Because of the capillary communication between the air space above the nutrient liquid and the outside air, this condition will be quickly corrected. As air flows out of the storage tank through the capillary outlet, the pressure diminishes, and the liquid which had risen into the air pressure tube in the tank is pushed out. Thus, within a short period of time, the pressure at the bottom of the storage tank is restored to its former value.

In this manner the Chemostat keeps the rate of flow of the nutrient liquid into the growth tube constant, independent of changes in barometric pressure and in the liquid level in the tank. The flow rate can be changed as desired by changing the water level in the pressure regulator.

Sickling: A Property of All Red Blood Cells

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Spontaneous sickling of red blood cells has been considered a property of the blood of certain individuals in Negro families, and various theories have been proposed to account for the phenomenon. New light may be thrown on the problem by observing the effect of thick gelatin "solutions" (e.g., Le Page's glue) on red blood cells. When a drop of blood of a *normal* individual is stirred with a drop of Le Page's glue (fishskin gelatin)[1] on a glass slide, the red blood cells immediately assume the sickle shapes (*1*) (see Fig. 1). The same phenomenon is noted with the blood of patients with sickle cell anemia, individuals with the sickle cell trait, cats, dogs, chickens,

[1] Specimens of Le Page's glue, as well as the purest form (Le Page's Photoengraving Glue) were furnished by N. C. Phillips, of Le Page's, Inc.

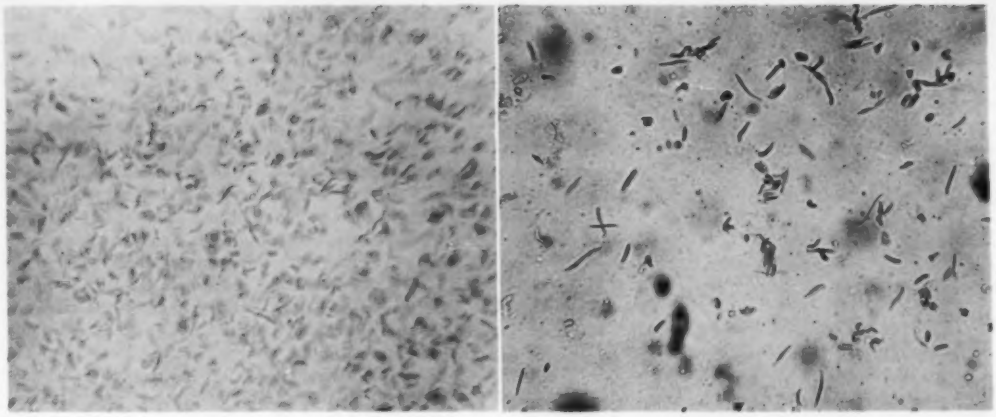

FIG. 1. Sickling of red blood cells of a normal white individual, on mixing with glue. (Microphotograph courtesy of George J. Anday.)

frogs, patients with spherocytosis, and human nucleated red blood cells. In blood with marked anisocytosis large and small sickled forms develop (Fig. 2). All the bizarre forms noted in sickle cell anemia are simulated (Fig. 3). A drop of Le Page's glue is placed on a glass slide, and a drop of blood (fresh, citrated, oxalated, or heparinized) is placed beside it. The two are then stirred together with a rod. Immediately, on examination, practically all the red blood cells will be found to have assumed the "sickle" shapes. Gelatin "solutions" of the same viscosity may be used.[2] These may be made by adding the smallest amount of hot water necessary to liquefy gelatin powder that contains urea as a liquefying reagent. If the gelatin is not viscous enough, the cells "sickle" for a few seconds and then become rounded.

In most preparations practically 100% of the red blood cells assume the sickle form. A permanent preparation may be made by rapidly drying thin films of the glue mixture, or by mixing the sickled cell suspension with formalin or with 1% osmic acid solution. If the freshly sickled cells are examined under a cover glass, it is seen that the cells eventually become spherical, fragment, and hemolyse. If a diluting agent (e.g., saline solution, plasma, albumin solution) is added to the glue, the cells do not sickle, and the phenomenon is not noted with mucilage or dilute gelatin "solutions." The sickling does not disappear if oxygen is bubbled through the suspension of sickled cells. If a diluting (saline) solution is added to the sickled cells, they become spherical or irregularly spheroid. The addition of concentrated glue to this mixture results in some of the cells resuming the sickle form.

The mechanism of the reaction is not clear, but two factors are evident at present: First, there is the mechanical factor of the cells being mixed with a very viscous solution and, second, the nature of the colloidal suspension.

[2] Mammalian gelatin for liquefication with urea was furnished through the kindness of Roy C. Newton, of Swift & Co.

The sickling with concentrated glue and gelatin solutions is similar to the reaction that is noted at times on the edge of a blood film of normal individuals. Frankly sickled forms, or red blood cells that are blunt at one end and elongated and narrow at the other end (the end pointing to the outside of the film), are evidently produced when the plasma dries slowly enough to allow for the concentration to affect the cells before they dry. The sickle forms that appear on the edge of the blood films of certain individuals who do not show the sickle cell trait are fairly constant for the individual, and their appearance varies with the humidity, with the rate at which the blood film dries, and possibly with other factors.

It was noted with mammalian gelatin "solutions" that some concentrations, more dilute than those that produce sickling, may cause all the red blood cells to assume

FIG. 2. Variation in size of "sickled" red cells produced in blood of a white man, with marked anisocytosis. (Osmic acid fixation.)

FIG. 3. Sickle and distorted forms of red blood cells produced with normal blood and glue solutions. (Microphotograph courtesy of George J. Anday.)

"pencil" shapes (elongated, with parallel sides, the length five or more times the width). Cells of this shape appear in a fractional percentage in blood of individuals who suffer from chronic hemorrhage.

This observation adds another form that normal red blood cells may characteristically assume under artificial conditions: spherical (including semispherical), crenated, and sickle-shaped. These differ from the more or less permanent abnormal forms, such as oval-shaped, "pencil" forms, grossly distorted forms, cells pointed at one end or at both ends (amphioxic), and "target" cells.

Whether this change in shape of the red blood cells has any relation to the condition in sickle cell trait or anemia remains to be elucidated by further study. In sicklemia there is apparently an intrinsic change in the red blood cells, whereas with glue the change is brought about by extrinsic factors.

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Synthesis of Anthracene-9-C_1^{14}

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Anthracene-9-C_1^{14} has recently been prepared in our laboratory for further experimental use as self-exciting crystal-counter material. Because the synthesis may be of interest to others, we wish to report the method used.

o-Toluic acid-carbonyl-C_1^{14} was prepared by carbonating a twofold excess of Grignard reagent obtained from *o*-bromotoluene with 10 millimoles of carbon dioxide containing 2 mc of C^{14}. After the reaction mixture was decomposed with ice and dilute sulfuric acid, and an ether solution of *o*-toluic acid obtained, the *o*-toluic acid was extracted into a threefold excess of 1 *N* sodium hydroxide. The *o*-toluic acid was then oxidized to phthalic acid by the addition of a 10% excess of 5% potassium permanganate solution. The excess permanganate was destroyed with ethanol, and the solution was filtered. The colorless filtrate was put in a small evaporating dish, and its volume reduced to 5 ml by warming in a current of air. Concentrated hydrochloric acid was added to precipitate the phthalic acid, which was filtered off. In order to obtain a more complete recovery of the labeled phthalic acid, ½ g of inactive phthalic acid was dissolved in the filtrate by heating, and a second quantity of phthalic acid was obtained on cooling. The combined acids were recrystallized from water and dried at 120° C. Yield was 1.9 g.

To convert the phthalic acid into anhydride, it was refluxed with twice its weight of thionyl chloride for 1 hr, after which 3 successive portions of benzene were distilled from the anhydride to free it from excess thionyl chloride. Benzoyl-benzoic acid was prepared from the anhydride by a Friedel-Crafts reaction using 10 ml of benzene and 3.8 g of aluminum chloride. The crude acid obtained was dissolved in dilute ammonium hydroxide, a small amount of diatomaceous earth was added, and the solution was filtered. Acidification with hydrochloric acid precipitated the benzoyl-benzoic acid as an oil, which crystallized on standing.

Anthraquinone was obtained from the benzoyl-benzoic acid according to the method of Dougherty and Gleason (*1*). The benzoyl-benzoic acid obtained was dissolved in 30 ml of 96% sulfuric acid and heated in an oil bath at 120° C for 1 hr. The reaction mixture was then poured into excess cold water, and the slurry digested on a hot plate. The anthraquinone was filtered, washed with warm dilute ammonium hydroxide, and dried at 120° C. Yield of anthraquinone was 2.1 g.

The anthraquinone was reduced to anthracene by a two-step reduction. Anthrone was prepared by the method of Meyer (*2*), using 50 ml of glacial acetic acid and 5 g of mossy tin. After being refluxed for 1½ hr, the solution was diluted with 25 ml of water, filtered hot, and allowed to stand overnight in a refrigerator. The anthrone, filtered and washed with water, was reduced to anthracene with copper-activated zinc and sodium hydroxide (*3*). To 10 g of zinc dust in a 200-ml, round-bottom flask, was added 10 ml of copper sulphate solution containing 0.04 g of $CuSO_4 \cdot 5H_2O$. After a few minutes, the solution was decanted, and the activated zinc was washed once with water by decantation. The anthrone from the preceding preparation, 80 ml of 2 *N* sodium hydroxide, and 20 ml of toluene were added. This mixture was refluxed for 24 hr. After cooling slightly, 20 ml of warm benzene was added, the liquid layers were decanted into a separating funnel, and the zinc was washed with another 20 ml of hot benzene.

The benzene-toluene layer was run into a flask, brought to a boil with 1 g of decolorizing charcoal, and filtered. The solvents were evaporated by a jet of nitrogen. The anthracene was then crystallized from 15 ml of toluene and was obtained as colorless, fluorescent flakes, mp 215° C. Yield was 1.3 g of anthracene having an activity of 0.9 μc/mg. When observed in a photographic darkroom after one's eyes are dark-adapted, this anthracene is seen to glow with a greenish-blue light.

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Applications of Nylon Catheters in Physiology of the Circulation[1]

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Recent years have seen the introduction of plastic materials into all phases of biological research. Of the innumerable plastics available, polyethylene (*1, 2, 3, 4*) and polyvinyl resins (*5, 6*) have been most widely used for catheters in circulatory research. As a result of extensive use of plastic catheters designed to be indwelling in blood vessels of various diameters, it was felt that an ideal catheter for vascular work should possess: flexibility; relative noncompressibility under manual pressure; ductility; suitability for chemical sterilization; translucency; suitability for use without special preparation; a nonwetting, smooth surface; radiopacity; nonirritability; availability; and low cost.

With the exception of radiopacity, which is seldom required, nylon catheters[3] have been found to possess all the desirable characteristics of the ideal catheter. Nylon catheters can be sterilized in cationic detergents prior to use, with no impairment of their desirable properties. They are translucent, and one can therefore easily follow the flow of blood or perfusing solutions. In addition, they are ready for immediate use and require no special preparations. They can be stretched to any specified length on a lathe, and their diameters thereby adjusted to pass through smaller-diameter needles if desired. In striking contrast to nylon, polyethylene tubing has been completely unsatisfactory for arterial work in that it is too soft, can be completely compressed, cannot be easily stretched, and does not yield a satisfactory pulse wave because of its flexibility. Polyvinyl is also inferior to nylon in that it requires special baking procedures to attain desired stiffness and it is usually not translucent after baking.

Nylon catheters have been used in experiments on unanesthetized dogs in which it was necessary either to draw repetitive arterial blood samples of 10–50 ml or to take continuous blood pressure recordings over a 4–5 hr period. The catheters were threaded up into the femoral artery through a 17-gauge needle used to make the initial arterial puncture. A wire stylet (type 302, spring temper) was inserted into the catheter to afford additional rigidity during insertion and was subsequently removed to permit the drawing of blood samples. To prevent extensive extravasation of blood through the puncture hole in the artery, intense manual pressure must be maintained over the area after insertion of the catheter. Even with removal of the wire stylet, no degree of direct manual pressure over the bleeding point can compress or kink the nylon catheters. Following insertion of the catheter into an artery, a blunt 20-gauge needle was threaded over the wire stylet and gently forced into the catheter with a slow rotary motion. It is essential that a catheter be somewhat elastic to permit the insertion of this needle adapter. With manual pressure maintained over the puncture area, the wire stylet was removed and a rubber-capped, modified luer-lock adapter (*7*) was attached to the 20-gauge needle and taped securely to the animal's leg. The nonwetting smooth surfaces of the catheters discourage platelet breakdown and coagulation of blood. Catheters have been left indwelling within arteries for up to 5 hr without significant plugging by clotted blood. The catheter assembly described is illustrated in Fig. 1. Catheters[4] with an outer diameter of 0.95 mm (0.037 in.) and an inner diameter of 0.51 mm (0.020 in.) were found to be most useful for both drawing of blood samples and recording of blood pressure. With repeated intra-arterial use of the catheters, there has been no evidence of tissue toxicity in a series of some 10 dogs. Arteries have healed adequately without obliterative thrombosis.

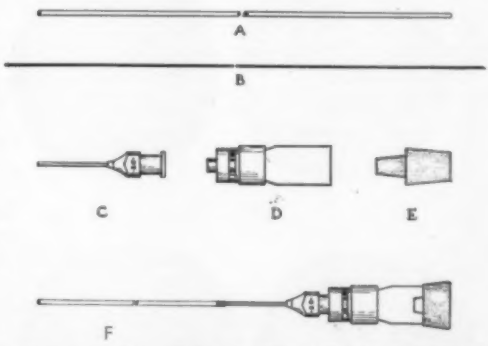

Fig. 1. Nylon catheter assembly. *A*, nylon catheter; *B*, wire stylet; *C*, blunt-end, 20-gauge needle adapter; *D*, short luer-lock glass adapter; *E*, serum cap; *F*, complete assembly.

[1] Aided by grants from the Office of the Surgeon General, Department of the Army, and the Chicago Heart Association.

[2] Present address: Department of Experimental Medicine, Northwestern University Medical School.

[3] Generously supplied by Elmer E. Mills of the Elmer E. Mills Corporation, Chicago, Ill.

[4] Can be obtained from John P. Marbarger, University of Illinois College of Medicine, Chicago.

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Prevention of the Phytotoxic Action of Sodium Orthophenylphenate on Citrus Fruits by Hexamine[1]

E. F. Hopkins and K. W. Loucks

Florida Citrus Commission, Lakeland and
Florida Citrus Experiment Station, Lake Alfred

A serious limitation to the use of sodium orthophenylphenate (Dowicide A)[2] solutions as dip treatments for the control of decay in citrus fruits is their tendency to cause chemical peel burn. When concentrations of the fungicide high enough to prevent stem-end rot and mold infections are used, severe burning of the fruit peel may be caused. Although this does not affect the internal quality of the fruits, their unsightly appearance renders them unmarketable. For this reason concentrations of the chemical greater than 1.2% have seldom been used in such treatments, and even this concentration is not always safe. In fact, even when the fruit was rinsed following treatment, peel burn on lemons has been reported (*1*) with concentrations as low as 0.5%.

In searching for a means of overcoming this difficulty, the authors have tried additions of a wide variety of materials to Dowicide A solutions. Some of these substances, such as vegetable oils, soap, waxes, and certain synthetic detergents, were found to have an effect in reducing the severity of injury to the fruit peel but were not reliable counteractants under all conditions, especially in the early part of the fruit season, when the fruit peel is more sensitive to chemical action. The experimental work reported here shows that hexamine (hexamethylenetetramine) is effective in preventing peel injury in citrus fruits by Dowicide A.

The incorporation of hexamine in fruit wraps, along with orthophenylphenol, to prevent scalding of the fruit peel, has been reported previously (*3*), but, so far as the present authors are aware, its use in fruit dips with Dowicide A has not been suggested. The addition of formaldehyde to Dowicide A solutions has been said to prevent peel burn in citrus fruits (*2*). However, in simultaneous tests made on the same lot of oranges, 100% of the fruit was badly burned when formaldehyde was tried as a counteractant, whereas no trace of injury occurred when hexamine was used.

It was found that the addition of a certain amount of hexamine to the Dowicide A solution entirely eliminated injury to fruits very sensitive to chemical peel burn. Following this discovery, some 45 experiments were carried out with Hamlin, Parson Brown, and Pineapple

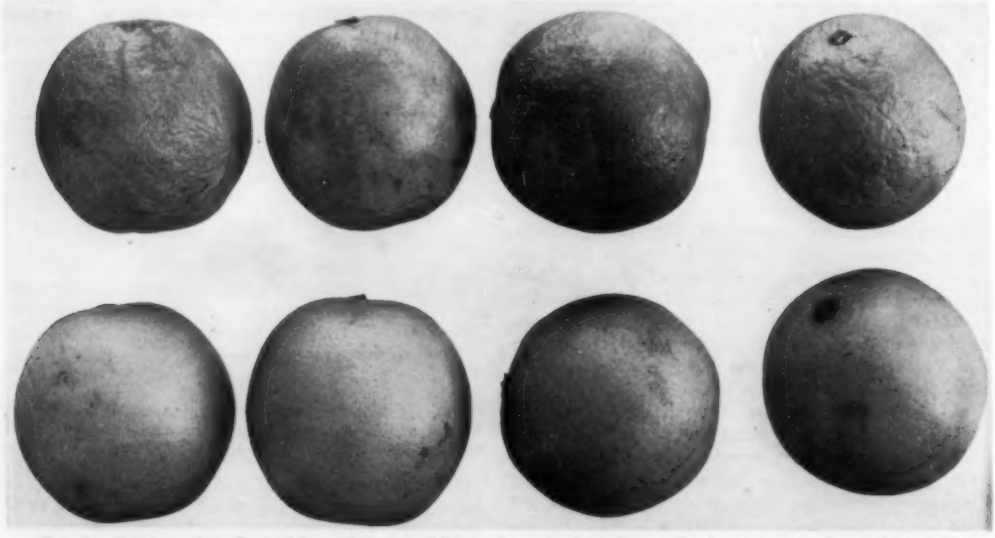

Fig. 1. Counteracting effect of hexamine on peel burn of oranges by sodium orthophenylphenate (Dowicide A): Above, 2% Dowicide A, 2 min at 100° F; below, 2% Dowicide A plus 1% hexamine, 2 min at 100° F.

[1] Cooperative investigation by the Citrus Commission and the Citrus Experiment Station.

[2] Acknowledgment is made to the Dow Chemical Company for kindness in furnishing samples of Dowicide A for this work.

varieties of oranges, and Dancy tangerines, to determine the reliability of the counteractant under various conditions and, at the same time, to evaluate the effect of the mixture on decay control. Approximately 30,000 individual fruits have been under observation. In no case has hexamine failed to prevent peel burn, even under severe conditions of treatment, namely, when the fruit was dipped in 2% Dowicide A for 2 min at 100°F and not rinsed after treating (Fig. 1). In one experiment a solution containing 3% Dowicide A and 1.5% hexamine was used as a dip, and the treatment made as just described. No trace of burn was produced on oranges so treated, whereas 1.5% Dowicide A without the counteractant caused severe burn on the same lot of fruit.

TABLE 1

Treatment	Total decay, %*
Controls, untreated	24.4
Dowicide A, 2%	4.9
Dowicide A, 2% + hexamine 1% .	3.7

* Stem-end rot and mold.

Data obtained from oranges held in storage for 3 weeks show that the addition of hexamine to the Dowicide A solution does not interfere with its fungicidal action on the organisms causing stem-end rot and mold decay. The mean values for 8 experiments are presented in Table 1. In all 8 experiments the oranges were subjected to an ethylene coloring treatment for 60–90 hr before receiving the fungicidal dip. This hastens the onset of stem-end rot decay and makes its control more difficult. As shown in Table 1, good protection against decay was also afforded by Dowicide A used alone, but in all cases the fruit was badly burned and of no value.

In addition to the results given in this paper, extensive data, to be published elsewhere, have been accumulated in respect to the factors involved in this Dowicide A–hexamine treatment. These data have shown that excellent control of both stem-end rot and mold decay are obtained when oranges are dipped in a solution containing 2.0% Dowicide A and 1.0% hexamine for 2 min at 100°F and not rinsed following treatment. A number of runs made in commercial packing houses have also shown a high degree of decay control without injury to the fruit peel.

An explanation of the remarkable effect of hexamine in preventing injury to plant tissues—in this case fruit peel—by Dowicide A, without interfering with fungicidal action, remains for future work. However that may be, the fact remains, and promises to give us a means of stopping the enormous economic loss from citrus fruit decay. We suggest also that it will find application in other instances where the use of Dowicide A is indicated.

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A Mouth-swabbing Technique for the Laboratory Mouse

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Although mouth-swabbing techniques are widely used, the literature contains no reports of the application of such methods to small laboratory animals. Inherent difficulties are directly related to the small size of the animal. Two of the most serious handicaps are possible injury to the animal and contamination of the swab by the animal's face and paws. A satisfactory technique should therefore consist of an adequate appliance and a method of handling that will insure reproducible samples without injury to the animal or contamination of the swab.

An appliance and a method that meet these requirements have been devised and are herewith described.

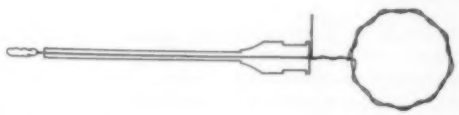

FIG. 1. Appliance diagrammed to show relations of parts when in mouth.

The device consists essentially of a cannula with a trochar and is analogous to the West nasopharyngeal swab (*1*). A 2-in., 18-gauge needle, which has had its end squared and dulled, is used as the cannula; the trochar is made of stainless steel wire of 0.013-in.

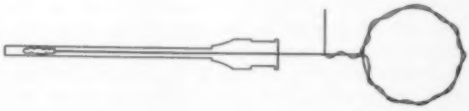

FIG. 2. Swab drawn back into needle for introduction to mouth.

diameter. The distal end of the wire, which can be projected beyond the end of the needle, is serrated and wound with a few strands of cotton to serve as the swab proper; the proximal end bears a stop and a loop (Fig. 1). The stop prevents the swab from being projected more than the predetermined ¼ in. beyond the end of the needle, and the loop allows the operator's index finger to manipulate the swab. To insure sterile dry swabs, it

[1] The opinions and assertions contained in this report are the private ones of the writers and are not to be construed as official or reflecting the views of the Navy Department or the naval service at large.

has been found most practical to autoclave first and then oven-dry the devices in packets of five.

Introduction of the appliance into the mouth of the animal is based on the observation that a mouse almost invariably will reach with his mouth and hold with his teeth any small article that is presented before him. In practice, the mouse is held in the conventional manner in the left hand, and the needle is held at its hub by the thumb and middle finger of the right hand with the index finger in the wire loop. With the swab drawn back into the needle (Fig. 2), the device is held before the

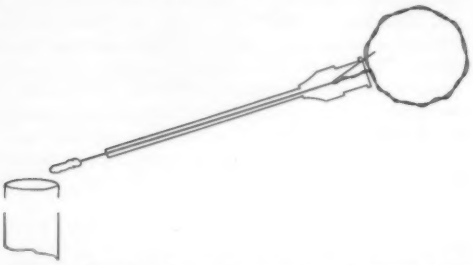

FIG. 3. Stop forced and cotton ready to be dropped into diluting fluid.

animal's face. When he reaches for it, he usually will grasp the end of the needle and begin to chew on it. At this point, the operator's index finger can push the swab gently out of the needle and into the animal's oropharynx. The stop will inform the operator when the swab is correctly positioned in the animal's mouth and will thus prevent injury caused by pushing the swab too far into the throat. It has been our experience that merely holding the swab in the mouse's mouth and allowing it to be tongued for 5 sec will insure a sample that will be as reproducible as any obtained by more elaborate manipulation. Before removal of the appliance from the animal's mouth, the swab is drawn back into the needle.

After removal, the swab is pushed about ¾ in. beyond the end of the needle by forcing the stop. Sterile forceps are used to pull the cotton off the wire and drop it into the diluting fluid (Fig. 3). After shaking the swab in the diluting fluid, an aliquot is plated on the culture medium of choice.

This appliance has been used with the Namru strain (*2*) of albino mice in studies to determine the relation between the oral flora, exposure to airborne pathogens, and the resulting degree of infection. In one exploratory test of the applicability of this technique, daily mouth swabs were cultured from 27 normal mice and from 20 mice that had been exposed for 15 min to a cloud containing *Streptococcus zooepidemicus* in a concentration of approximately 3×10^3 organisms per liter of air. The swabs were shaken in 10 ml of nutrient broth, and 0.1 ml aliquots were dallied on 5% cow blood agar and incubated at 37° C for 24 hr. Of the normal animals, 90% produced less than 3×10^2 β-hemolytic colonies per swab during the 3-week experimental period. On the other hand, counts from the infected animals showed an upward trend until, at the end of the 3 weeks, 11 of the 12 survivors produced between 2×10^4 and 2×10^5 β-hemolytic colonies per swab. The 8 nonsurvivors died within 5 days after exposure; their counts during this period were comparable to those of the survivors sampled simultaneously. In addition to colonies showing β-hemolysis, other colonial types were noted on most plates.

The fact that a trend could be discerned in the infected animals, together with the observation of various colonial types from both normal and infected animals, indicates that this mouth-swabbing technique should allow satisfactory sampling of the oral flora of mice. Further studies will be reported at a later date.

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A Method for Artificial Insemination in Viviparous Fishes[1]

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The American Museum of Natural History, New York

The practice of successful artificial insemination in man and in certain domesticated mammals, particularly horses and cattle, is well known, and the artificial insemination of bees is a common practice of apiculturists (*1*). The technique has also been used effectively in poultry for the study of intraspecies competition among sperm of different breeds (*2*).

Methods for the external artificial fertilization of a variety of invertebrate eggs and those of a number of oviparous poikilothermic vertebrates have been widely employed by experimental embryologists, pisciculturists, etc. However, the artificial insemination of viviparous cold-blooded vertebrates (or poikilothermic vertebrates which lay fertilized eggs) has never, to the writer's knowledge, been previously reported.[4]

In the course of studies on the sexual-isolating mechanism between the sympatric species of poeciliid fishes, *Platypoecilus maculatus* and *Xiphophorus helleri* (*3, 4, 5*), interspecies sperm competition appeared to be a significant factor. Cross-species matings and the pro-

[1] This study was supported in part by a grant from the Committee for Research in Problems of Sex, National Research Council, made to Lester R. Aronson.

[2] AEC postdoctoral research fellow in the Biological and Agricultural Sciences of the National Research Council; sponsored by The American Museum of Natural History.

[3] The writer wishes to express her gratitude to Dr. Aronson and to Myron Gordon for many helpful suggestions. Dr. Gordon, of the New York Zoological Society, supplied the fishes used in this study.

[4] After this paper went to press, it was called to the writer's attention that a paper in Russian (*10*) reports hybridization between *X. helleri* and *P. maculatus* by means of artificial insemination.

TABLE 1

RESULTS OF THE ARTIFICIAL INSEMINATION OF 19 *Xiphophorus helleriі*

♀	No. and species of donor*	Date of insemination	Dates of broods and no. of young†			Comments
			1st brood	2nd brood	3rd brood	
7	1 P.m.	2/1	3/13 (12)‡	—	—	♀ died 5/17; had no embryos
8	1 P.m.	2/1	—	—	—	No broods as of 7/24
9	1 X.h. + 1.5 P.m.	2/1	2/23 (12)	3/21 (19)	4/17 (11)	
10	1 X.h. + 1.5 P.m.	2/1	3/28 (6)	—	—	
11	1 X.h. + 2 P.m.	2/25	4/12 (23)	5/6 (15)	6/4 (22)	
12	1 X.h. + 2 P.m.	2/25	—	—	—	♀ died 4/11; had no embryos
13	1 X.h. + 2 P.m.	2/25	4/ 7 (11)	—		
14	1 X.h. + 2 P.m.	2/25	4/ 4 (14)	5/2 (3)	7/20 (1)	
18	1 X.h. + 2 P.m.	2/25	3/23 (17)§			
19	1 X.h. + 2 P.m.	2/25	3/22 (12)‖			♀ died 3/22
15, 16, 17, 20	1 X.h. + 2 P.m.	2/25				No broods as of 7/24
22	3 P.m.	3/6	4/7 (1)‡			
24	3 P.m.	3/6	4/24 (26)‡	5/22 (17)‡	6/20 (8)‡	
21, 23, 25	3 P.m.	3/6				No broods as of 7/24

* P.m. = *P. maculatus*; X.h. = *X. helleriі*.
† Except where otherwise indicated, the young are *X. helleriі*.
‡ Hybrid young.
§ One of these young is a hybrid.
‖ Embryos found in dead ♀.

duction of hybrid broods from these two species occur infrequently under limited laboratory conditions. An experimental investigation of the problem of sperm competition, therefore, could be greatly facilitated in these viviparous fishes by a method for controlled inseminations. In the past, several investigators—including the writer (*6*)—have failed to produce broods by artificially inseminating females of *P. maculatus* and *X. helleriі*, although they used large quantities of spermatophores. We have now developed a method of artificial insemination in *X. helleriі* that has proved reasonably successful.

The compact clusters of spermatozoa (called spermatophores) of the male *P. maculatus* or *X. helleriі* are squeezed out by pressing slightly on the bases of the pelvic fins and pivoting the gonopodium into the forward position. This releases hundreds of spermatophores, which usually flow into a groove formed on either the left or right side of the gonopodium. By means of a rubber tube held in the experimenter's mouth at one end, and attached to a micropipette at the other, the spermatophores can be gently sucked into the pipette and placed in a drop of 0.8% NaCl solution. The spermatophores of 1–3 males are used to inseminate each virgin female. The spermatophores are all added to the same drop of saline solution, wherein they start breaking up, and in less than 1 min highly motile spermatozoa can be observed swimming freely. The drop of saline-sperm solution is then gently sucked up and blown out of the micropipette twice in order to hasten the breaking up of the remaining clusters and to ensure adequate mixing of spermatozoa. Finally, the saline-sperm drop is injected into the genital opening of the female with the same micropipette. The females are then placed in individual aquaria and are well fed with daphnia; when the young are born they are separated from the mother to prevent cannibalism.

Table 1 shows the results of 19 attempts to artificially inseminate *X. helleriі* females. It is known that poeciliid females store sperm for long periods and may continue to drop as many as 8 broods (at approximately 28-day intervals) after being paired with a male for a day or two. It has been found, however, by the use of a smear technique to check for sperm in females after a copulation (*3*), that single inseminations resulting from normal copulations do not always produce broods (*5*). In view of these facts, the preliminary results on artificial inseminations are encouraging. The production of broods in over 50% of the trials indicates that this method may serve as a useful tool in the study of sperm competition, and further experiments are now in progress. *X. helleriі* and *P. maculatus*, as well as a number of closely related forms, are the subjects of extensive genetic studies in fishes (*7, 8, 9, 11*). It is hoped that this method of artificial insemination may be helpful in facilitating these genetic studies, particularly where the breeding of certain strains and hybrid combinations by natural methods has not been successful.

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Comments and Communications

The Accessibility of Knowledge

The enclosed is a copy of a letter just mailed to Professor W. Missiuro. This, I believe, is self-explanatory and it may be that you will wish to publish it in SCIENCE. I, at least, am greatly disturbed to see such evidence of growing chauvinism in science in some parts of the world and feel we scientists should be alert to express such concern.

ANCEL KEYS

UNIVERSITY OF MINNESOTA
LABORATORY OF PHYSIOLOGICAL HYGIENE
MINNEAPOLIS 14, June 27, 1950

Professor W. Missiuro, Editor
Acta Physiologica Polonica
Akademia Lekarska
Zaklad Fizjologii Czlowieka
Krakowskie Przedmiescie 26/28
Warszawa, Poland

DEAR PROFESSOR MISSIURO:

I have received the first issue (Volume 1) of *Acta Physiologica Polonica* and hasten to send good wishes to you and your associate editors in this new venture. I note that the work is well printed on good paper and presents altogether a pleasing appearance. All of this may be taken as another indication that Poland is indeed recovering from the destruction and chaos wrought by the war.

We are fortunate that Dr. Josef Brožek, Associate Professor here, reads Polish easily. I suppose that, outside of Poland and possibly Russia, there are scarcely twenty physiologists in the world who are expert in that language. Aside from the Latin title, your *Acta* is wholly in Polish, without even brief summaries of the articles in any other language.

The fact that Polish uses the Latin script makes it possible for me to discern, with some difficulty, that your first volume of the *Acta* is entirely devoted to the Russian physiologist I. P. Pavlov. What do your contributors have to say about Pavlov? Do they remind us that Pavlov's genius, like that of all great men of science, had no boundaries of nationality or language? Or is it now thought that Pavlov's contributions to knowledge may be called back, to be confined to the east of the Oder-Neisse Line?

By the same post that brought Volume I of your *Acta*, I received Number 34 (9, April, 1950) of *Endeavour*. On the first page (53) is this issue's Editorial, entitled "The Accessibility of Knowledge." Perhaps I should quote the first sentence: "The first task of a scientist entering a field of research is to master the facts already discovered by earlier workers and then to keep abreast of the discoveries of his contemporaries pursuing the same line." This is a large and difficult assignment at best; I wonder how we are to meet the problem created by publication wholly in a language which is unintelligible to the overwhelming majority of potential readers.

I am reminded also of a very recent article in *Chemical and Engineering News* (28, 1369 [1950]) by Francis Boyer, who says: "The scientist must accept a social as well as a scientific duty. He cannot limit his responsibility to advancing knowledge; he is responsible, too, for its dissemination."

We scientists have had a long history of trouble with intercommunication. For centuries we tried to manage with Latin as our lingua franca; there were few of us then and the volume of our intercommunications was very small. In modern times the overwhelming majority of our scientific discoveries and theories have been published in English, French, and German, with Italian and Spanish as much less important alternates. Lately, some of us are thinking that we ought to learn Russian as well, but, as you know, it is difficult enough to learn modern science alone without the added burden of years of purely language study.

From the above you will understand that we greet your new *Acta* with mixed feelings. Although we wish every success to the progress of physiology in Poland and to the success of the *Acta*, we cannot help regretting that most of us will, because of the language limitation, be unable to follow your progress in the *Acta*.

With my personal good wishes, I am

Sincerely yours,
ANCEL KEYS, *Director*

Amylase Inhibition

A statement by Volker (*Science*, 112, 61 [1950]) that indole acetic acid, indole butyric acid, and indole propionic acid have antiamylytic ability requires additional comment. The antiamylytic ability of these auxins is due entirely to pH effect (Eyster, H. C. *Plant Physiol.*, 21, [1], 68 [1946]). The antiamylytic character of 2, 4, dichlorophenoxyacetic acid, triiodobenzoic acid, naphthalene acetic acid, naphthoxyacetic acid, and nicotinic acid may also be due solely to pH effect. There may be *in vivo* inhibition of amylase that is not dependent upon pH effect; however, *in vitro* auxin retardation of diastase is correlated with pH.

H. C. EYSTER

The Charles F. Kettering Foundation
Yellow Springs, Ohio

Rhetorical Atrocity

Recent scientific literature (I hesitate to mention names) has repeatedly included the verb *to hypothecate*, evidently intended to mean *to make a hypothesis*. What possessed the author who first perpetrated this atrocity?

The correct, though phonetically awkward, verb is *to hypothesize*. If only our venerable authors, referees, and editors would condescend to consult a dictionary, they would learn, much to their amazement and disgrace, that *to hypothecate* means *to assume a mortgage!*

WOLF VISHNIAC

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New York University Bellevue Medical Center

Book Reviews

Principles of Genetics. 4th ed. Edmund W. Sinnott, L. C. Dunn, and Th. Dobzhansky. New York: McGraw-Hill, 1950. 505 pp. $5.00.

In this new edition of the classical textbook of Sinnott and Dunn, Professor Dobzhansky has joined the original authors in the difficult task of bringing the subject matter up to date. The authors have eminently succeeded in this ambitious undertaking. A comparison of the present edition with previous ones serves best to demonstrate the enormous changes genetics has undergone in the past decade.

All too frequently in revising a text, the author is satisfied when he simply adds one or two chapters containing the new developments in his science. Often these chapters are not closely connected with the remainder of the book, which continues to describe its subject matter from an older point of view. This danger has been avoided in the present edition, with the result that the newer fields of genetics are presented so as to form an integrated part of the whole science.

The first ten chapters follow the logical sequence of earlier editions by first developing the methods and results of "formal" genetics and then proceeding to the discussion of the chromosome theory of heredity. The genetics of microorganisms, *Neurospora*, bacteria, and viruses are first introduced in this part. Examples from human genetics are found scattered throughout these chapters in appropriate places, emphasizing the fact that the laws of genetics apply to all organisms, including man. The chapters dealing with chromosome behavior have been profoundly altered, incorporating the vast amount of knowledge accumulated on chromosomal rearrangements, and their bearing on the arrangement of genes in the chromosomes.

Chapter 11 is devoted to mutations. Chapters 12–14 give a condensed and clear account of the problems and results of the field of population genetics and of its bearing on evolution. The modern theory of evolution is developed in a straightforward manner. The discussion of inbreeding and heterosis, which in earlier editions formed an unconnected chapter, is incorporated in the description of population genetics. This field is presented logically, as a natural consequence of the principles developed in the earlier chapters, and should offer no difficulty to the student.

An outstanding feature of *Principles of Genetics* is the group of 4 final chapters dealing with physiological and developmental genetics. The vast amount of material obtained in this field has not been treated adequately in any other text. As a matter of fact, no complete synthesis of developmental genetics has been attempted during the past decade, and it is therefore gratifying to read this first integrated presentation from a modern point of view.

Most of the chapters are supplemented by a large number of problems, which serve not only as exercises for the principles learned in the chapter but frequently will lead to amplifications and discussions. A bibliography of a number of significant books and papers in the field covered accompanies each chapter. Illustrations were selected with great care and are well executed. As an appendix, a translation of Mendel's classical paper has been reprinted. It is to be hoped that many teachers will make use of this opportunity to introduce to their students the beautifully clear logic and presentation and the great experimental skill of Gregor Mendel.

Teachers of genetics will be gratified to find that they have here for the first time a textbook of genetics adequately representing the facts and principles of classical genetics as well as the more recent findings and problems of our own time. It is to be hoped that this book will be widely adopted in college classes.

ERNST CASPARI

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Handbook of Psychological Research on the Rat: An Introduction to Animal Psychology. Norman L. Munn; Leonard Carmichael, Ed. Boston: Houghton Mifflin, 1950. 598 pp. $7.50.

The word "handbook" as used in the title to this volume may suggest misleading notions about its make-up. You could not fairly say that it is not a handbook, but you could truthfully say that it is not similar in tabular and formulae content to such works as Hodgman's *Handbook of Chemistry and Physics.* It is, rather, a review and hence possesses limitations imposed by the author's task of selecting what to include from each study and then of judging what studies bear on what topics.

The book, according to Munn, is a complete survey of psychological research on the rat. Following the introductory chapter (a discourse on the general nature of research and on the care and handling of laboratory rats), the book contains the author's abstracts, evaluations, and interpretations of almost 2,600 research studies arranged under many subheadings of 9 topical headings: "Unlearned Behavior;" "General Activity;" "Motives, Emotions, and Hoarding;" "Sensory Processes;" "Sensory Processes in Maze Behavior;" "Learning;" "Some Aspects and Conditions of Learning;" "Systematic Psychology;" and "Abnormal and Social Behavior." There are 3 appendices containing, respectively, 52 references for books on comparative psychology, some additional (other than rat) references on comparative psychology, and the bibliography. Both author and subject indices appear.

A knowledge of the general manner in which Munn presents the research material may be gained from a description of Chapter II, which is entitled "Unlearned Behavior." The 190 studies mentioned in this 42-page chapter are assembled under the subheadings of fetal behavior, behavior observable at birth, male sexual behavior, female sexual behavior, reproductive behavior, inheritance of the effects of training, inheritance of induced

degeneracy, and tropistic behavior. Each of these subtopics is introduced with appropriate definitions, background materials, or problems, and then the studies of factors influencing or concerning the topics are presented. A noteworthy thing about the chapter, as about the others of which it is typical, is the amount of information Munn has been able to include on methodology as well as on findings and problems of so many research studies.

As to functions for which the book is adaptable, it would appear to be most useful to the investigator who already has a "problem" and wishes to know what work with the rat has a bearing on it. It should also be valuable to the advanced student and to the theorist as a reference source. Likewise, it should be of aid to the careless or forgetful teacher who has not kept his reference files in good shape. It cuts across too many course-areas in the curriculum of psychology to be indicated as a general textbook.

JOHN B. WOLFF

Department of Psychology
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Die Welt der Vektoren: Einführung in Theorie und Anwendung der Vektoren, Tensoren und Operatoren. Franz Ollendorff. Vienna, Austria: Springer-Verlag, 1950. 470 pp. $9.00 paper; $9.60 bound.

This book on vector and tensor analysis not only covers the algebra and calculus of vectors and tensors, but is especially rich in its applications, which range over affine space and the spaces of Minkoroski, Riemann, and Hilbert. The mathematical treatment is brief and largely formal; differentials and increments seem to be interchangeable, and the basic integral theorems are proved with but slight regard to rigor and are stated as if universally applicable to all kinds of functions and quite arbitrary regions. The distinction between necessary and sufficient conditions is not always sharply drawn. For example we are shown (p. 58) that div rot $V = O$; the next sentence assures us that, "conversely," the differential equation div $W = O$ has the *general* integral $W = \text{rot } V$, but without a word of proof or even a suggestion that there is anything to prove. Similarly it is taken for granted (p. 319) that a Riemannian n-space can always be embedded in a Euclidean $n(n+1)/2$-space.

The notation used makes the book very trying to read—scalars are denoted by Roman type, vectors by italic. In a complicated page of symbols these distinctions do not stand out as well as when the usual practice of denoting vectors by bold-face type is followed. Parentheses and brackets are used for the scalar and vector products instead of the customary dot and cross between the factors. The latter notation of Gibbs, which leaves the signs of aggregation for their proper uses, is gradually winning adherents in various parts of the world and seems destined to become standard.

In spite of these shortcomings the book is a valuable addition to the literature of vector analysis. The applications are very numerous and their scope is truly impressive, for they cover much of the "world" of mathematical physics: classical mechanics, space lattices and crystal structure, hydrodynamics, elasticity, Minkoroski's electrodynamics (special relativity), a brief glance at the gravitation problem (general relativity), electrical networks, and finally quantum mechanics. Even when the treatment is not too lucid and convincing, it is often suggestive and plausible. The book will be especially useful to those who are already somewhat familiar with the subject matter. The reader who approaches these matters for the first time will find the going quite rough.

LOUIS BRAND

Department of Mathematics and Mechanics
University of Cincinnati

Scientific Book Register

Economic Aspects of Atomic Power. Sam H. Schurr and Jacob Marschak. Princeton, N. J.: Princeton Univ. Press, 1950. (For the Cowles Commission for Research in Economics.) 289 pp. $6.00.

Encyclopedia on Cathode-Ray Oscilloscopes and Their Uses. John F. Rider and Seymour D. Uslan. New York: Rider, 1950. 982 pp. $9.00.

Marine Geology. Ph. H. Kuenen. New York: Wiley; London: Chapman & Hall, 1950. 568 pp. $7.50.

Carotenoids. Paul Karrer and Ernst Jucker; trans. and revised by Ernest A. Braude. New York: Elsevier, 1950. 384 pp. $8.50.

Deciduous Forests of Eastern North America. E. Lucy Braun. Philadelphia: Blakiston, 1950. 596 pp. $10.00.

Oral Pathology: A Histological, Roentgenological, and Clinical Study of the Diseases of the Teeth, Jaws, and Mouth. 3rd ed. Kurt H. Thoma. St. Louis, Mo.: Mosby, 1950. 1,592 pp. $17.50.

Colloidal Dispersions. Earl K. Fischer. New York: Wiley; London: Chapman & Hall, 1950. 387 pp. $7.50.

Progress in Biophysics and Biophysical Chemistry, Vol. I. J. A. V. Butler and J. T. Randall, Eds. New York: Academic Press; London: Butterworth-Springer, 1950. 279 pp. $6.80.

Colorimetric Determination of Traces of Metals. 2nd ed. E. B. Sandell. New York: Interscience, 1950. 673 pp. $9.00.

Progress Volume: Modern Developments in Therapeutics and Methods of Treatment. Companion volume to "An Integrated Practice of Medicine." Harold Thomas Hyman. Philadelphia: Saunders, 1950. Pp. 4133–4867. $10.00.

A Manual of Physics. 5th ed. J. A. Crowther. New York: Oxford Univ. Press, 1950. 594 pp. $4.25.

How to Develop Your Thinking Ability. Kenneth S. Keyes. New York: McGraw-Hill, 1950. 246 pp. $3.50.

Principles of General Psychopathology: An Interpretation of the Theoretical Foundations of Psychopathological Concepts. Siegfried Fischer. New York: Philosophical Library, 1950. 327 pp. $4.75.

News and Notes

Joint Statement by the Department of the Navy and the United States Atomic Energy Commission

One very essential condition for maintaining our national strength, whether for peace or for war, is that the research in the sciences which is basic to all technological progress be kept at a high level. Such research is now in progress in many universities, private research establishments, and other laboratories throughout the nation. By this research we add to our store of scientific knowledge and increase the number of highly trained persons available to the nation in time of need. The scientist in his laboratory and the research professor with his graduate students are performing a service which may make a critical difference to our country in the difficult years ahead.

In particular, the Department of the Navy and the Atomic Energy Commission consider a high level of basic research in the sciences essential to the continued progress of their respective programs.

DEPARTMENT OF THE NAVY
D. A. KIMBALL, *Undersecretary*
U. S. ATOMIC ENERGY COMMISSION
GORDON DEAN, *Chairman*

Hugh Huffman Memorial Calorimetry Conference

Daniel R. Stull

The Dow Chemical Company, Midland, Michigan

The Fifth Calorimetry Conference, designated as the Hugh Huffman Memorial Meeting in honor of the late Hugh Martin Huffman, who initiated and presided over the earlier meetings of the conference, was held at the Technological Institute of Northwestern University, Evanston, Illinois, on September 5. Sessions were attended by more than 65 representatives of approximately 40 university, industrial, and governmental laboratories in all parts of the U. S. The first speaker was George S. Parks, of Stanford University, who gave an interesting summary of Dr. Huffman's life.

George Furukawa, of the National Bureau of Standards, described the calorimetry program being carried out at the Bureau for the temperature range 1°–20° K. The purpose of this program is to improve, if possible, the precision of measurement to 0.1% and to investigate the electronic contribution to the heat capacity of superconductors and alloys of transition elements. More accurate as well as more sensitive thermometers are to be developed for the low-temperature range. The plans, under the direction of R. B. Scott and B. Kurrelmeyer, call for the more accurate determination of vapor pressure-temperature relation for hydrogen and helium on the thermodynamic scale, and the development of secondary thermometers. The calorimeter, which is under construction, will contain a helium thermometer, as well as a phosphor-bronze resistance thermometer to cover the helium range and a constantan resistance thermometer to cover the hydrogen range. It will have a capacity of approximately 100 ml of sample. Calibration above 20° K will be made with the gas thermometer. Allan C. Werner, of the Barrett Division, Allied Chemical & Dye Corporation, described the calorimetry from 25° to 300° C practiced by his company.

Dr. Furukawa also reported on the progress of the heat capacity measurements of the standard substances which will be issued by the Bureau of Standards. At the Third Calorimetry Conference, *n*-heptane, benzoic acid, and synthetic sapphire were selected as the standards for comparison of the heat capacity of calorimeters. *N*-heptane and benzoic acid are to be used in the temperature range of 10°–340° K, and the sapphire, 10°–1800° K. These materials are available in limited quantities free to qualified laboratories, with the stipulation that the calorimetric data be available to the Bureau for evaluation. The heat capacity measurements at the Bureau with sapphire and benzoic acid have been completed, and the data are now in the last stages of preparation for publication.

J. G. Aston, of Pennsylvania State College, presented a comparison of the adiabatic and isothermal calorimeters. He pointed out that both these methods of calorimetry are capable of equal precision, but that each method is best suited to particular types of measurement. The isothermal calorimeter is best suited to measure heat of combustion, heat of reaction, low-temperature heat capacity, heat of adsorption, and the heat capacity of gases, whereas the adiabatic calorimeter is best suited to measure the heat of reaction, low-temperature heat capacity, the heat capacity of solutions, and the heat of adsorption.

The afternoon session began with the business meeting, at which Daniel R. Stull was reelected chairman of the conference for another year. The group decided not to restrict the conference to low-temperature calorimetry, but to open it to problems of calorimetry at all temperatures, since all calorimetry is based on the same laws of heat flow. Discussion arose concerning the publishing of calorimetric data. Some of the members had encountered reluctance on the part of certain editors to include tables of experimental information.

George Guthrie, of the U. S. Bureau of Mines, described the machine computation of resistance versus temperature tables for platinum resistance thermometers from 15° to 90° K. Julian M. Sturtevant, of Yale University,

explained a new calorimetric method for measuring heats of reactions. A twin calorimeter has been designed specifically for measuring heats and rates of liquid phase protein reactions. The calorimeters contain only 30 ml of solution each, and are of metallic (tantalum) construction insofar as possible, to minimuze thermal lags. They are supported within an aluminum jacket, the temperature of which is automatically held equal to the mean of the calorimeter temperatures. The temperature difference between the calorimeters is measured by resistance thermometers in an alternating current bridge. The results obtained indicate that endothermic or exothermic reactions having half times between 3 minutes and several hours can be handled, provided the heat effect is large enough. With reactions having half times of the order of several minutes, satisfactory measurements can be obtained with a total heat absorption or evolution of as little as 0.0008 calorie per ml of reacting solution. The precision of measurement of the heat effect of this magnitude appears to be of the order of a few percent for a process with clean-cut kinetics. Rate constants comparing favorably in accuracy with those yielded by other methods are obtained.

Frederick C. Schmidt, of Indiana University, described a liquid ammonia calorimeter (next to water, anhydrous liquid ammonia is the best of the common ionizing solvents for salts). A liquid ammonia calorimeter designed by C. A. Krause and improved by Professor Schmidt has been in use for some 20 years. The calorimeter is adiabatic, and the measurement of the heat effects depends upon the heat of vaporization of liquid ammonia. Heats of solution and reaction have been measured close to the boiling point of the solvent, and the heat effects of the rapid processes are determined by measuring the amount of gas evolved by the heat of reaction. Corrections for the change in the heat content of calorimeter and solution are made from the "calorimeter constant" and the specific heat of the solution.

Edgar F. Westrum, Jr., of the University of Michigan, described an adiabatic semimicro calorimeter, developed at the Argonne National Laboratory, in which the entropy and low-temperature heat capacities of neptunium dioxide were measured. This adiabatic semimicro calorimeter for measuring low-temperature capacities of 0.01 mole samples of neptunium compounds employs only liquid helium and liquid nitrogen as refrigerants for measurements in the range 4°–320° K. Temperature measurements were made with a strain-free platinum resistance thermometer which was an integral part of the calorimeter.

Phillip N. Andress, of the Rubicon Company, described a 6-dial thermo-free potentiometer for low-voltage thermocouple measurements. This instrument has ranges from 0 to 111,111.0 mv in steps of 0.1 mv, and 0 to 11,111.10 mv in steps of 0.01 mv. The limits of error are, for the high range, 0.01% of the reading plus 0.1 mv, and for the low range, 0.01% of the reading plus 0.02 mv. Thermal electromotive forces are less than 0.01 microvolt. Malcolm Dole, of Northwestern University, described an automatic adiabatic calorimeter that had been developed with the cooperation of W. P. Hetinger, Jr., N. R. Larson, and J. A. Wethington, Jr. This calorimeter has been set up for the measurement of specific heats and heats of transition of solid high polymers. Randolph C. Wilhoit, of Northwestern, discussed the use of a watt-hour meter in conjunction with this calorimeter. A specially constructed Sagimo watt-hour meter capable of measuring power to 0.1%, from 20% to 150% of full load, was used. The pointer on the watt-hour meter reflects a light beam to a photoelectric cell which turns the power into the calorimetric heater for an integral number of revolutions of the pointer shaft, each revolution corresponding to 51.61 cal/rev ± 0.25%. Mr. Wilhoit also described the effects of 60-cycle harmonics on the behavior and accuracy of the meter and reported having discovered harmonics as high as the 28th in the source of heating power that was being used.

John C. Melcher, of the Leeds & Northrup Company, traced the development of their new precision resistance recorder from the time of its description by D. R. Stull in 1945 until its trial by the Physical Research Laboratories of The Dow Chemical Company. As described by Albert J. Williams, Jr., the instrument will record d-c resistance continuously over the range 0–100 ohms with sensitivity of 0.001 ohms. Accuracy of measurement is 0.02% of the absolute resistance value, which is equivalent to 0.05° C with nominal 25-ohm platinum resistance thermometers. Changes in temperature can be read to 0.01° C. The temperature range of such a 25-ohm platinum thermometer is from 12° K to 500° C. Ice point to steam point in 36 sec is typical response requiring both slide wire and decade operation. The accuracy is comparable to the G-1 laboratory-type Mueller bridge, but sensitivity is not as good (0.001 ohm, compared to 0.0001 ohm). Inspection of the instrument by members of the conference followed the adjournment.

Scientists in the News

The National Bureau of Standards recently received the following visitors from abroad: **Ake Ekelund** and **Olle Sturen**, Swedish Standards Association, Stockholm; **Frederic Fournier**, Overseas Territories Scientific Research Bureau, Paris; **J. B. Le-Poole**, Institute of Technology, Delft; **Hubert Moulinier**, Agronomic Institute, Seaboard Division, Bingerville, Ivory Coast, French West Africa; **Claude S. Moureaux**, Institute of Research, Madagascar; **Jan Ollner**, Swedish Electrotechnical Commission, Stockholm; and **A. van Rossem**, Delft.

Bentley Glass, of the Department of Biology, The Johns Hopkins University, left last week for Germany, where he will spend two months as a scientific consultant attached to the Science Research Branch of the Office of the High Commissioner.

Shinkishi Hatai has resigned as representative of the Science Council of Japan on the Pacific Science Council. He is succeeded by **Koji Hidaka**, professor of physical oceanography at Tokyo University.

Ford M. Milam, formerly head of the Department of Agronomy at the cooperative station between the U. S. government and the republic of El Salvador, has joined the Indian Council of Agricultural Research,

New Delhi, to assist with the coordination and improvement of agricultural research in that country. Mr. Milam is an employee of the OFAR.

Philip N. Powers, personnel adviser to the AEC, is now with the National Security Resources Board, where his job is to draft advice to President Truman on utilization of scientific personnel during partial or total mobilization.

John W. Streeter, formerly of Vassar College, has been appointed assistant director of the Fels Planetarium and assistant associate director in charge of astronomy and seismology of the Museum of the Franklin Institute.

Charles H. Wilson, vice president of Corpus Christi College, Oxford, England, has been appointed visiting professor of political science at Ohio State University. Dr. Wilson will teach during the winter and spring quarters.

Meetings

Student bodies in medical schools of the U. S. will send delegates to a meeting in Chicago, December 28–29, to draft a constitution for the **Student American Medical Association.** The meeting will be held in the AMA headquarters, and the organization will be affiliated with the AMA. Walton Van Winkle, Jr., secretary of the AMA Committee on Research, is serving as temporary executive secretary of the student association during its preorganization period.

Mount Sinai Hospital's tenth series of Wednesday evening lectures on **Recent Advances in Surgery** is being presented at the hospital's Blumenthal Auditorium at 8:30 P.M. The program is as follows: Dec. 20, Frederick A. Coller, Ann Arbor, "Use and Abuse of Parenteral Fluids in Surgery;" Jan. 3, Julian Johnson, Philadelphia, "Cardiac Resuscitation;" Jan. 17, Jacob Fine, Boston, "Effect of Vascular Integrity of the Gut;" Jan. 24, Brian Blades, Washington, D. C., "Aneurysms and Arteriovenous Fistulas of the Lung;" Feb. 7, Willis J. Potts, Chicago, "Surgical Treatment of Congenital Heart Disease;" Feb. 21, Frank L. Meleney, New York, "Importance of Laboratory Data in the Treatment of Surgical Infections by Antibiotics;" and March 7, Claude S. Beck, Cleveland, "Operation for Coronary Artery Disease."

At the 33rd annual meeting of the **National Malaria Society,** in Savannah, Ga., November 6–10, the following officers were elected for 1951: president, Justin M. Andrews, Atlanta; president-elect, W. H. W. Komp, Bethesda, Md.; vice president, E. L. Bishop, Chattanooga; and secretary-treasurer, S. W. Simmons, Savannah.

Paul B. Christensen, vice president and chief engineer of Merchants Refrigerating Company, New York City, became president of the **American Society of Refrigerating Engineers** on December 6. Installation ceremonies, conducted by retiring president John G. Bergdoll, Jr., were one of the concluding events of the 46th annual meeting of the Society, held in New York, December 3–6. Other officers for 1951 are: vice presidents, Edward Simons, consulting engineer, San Francisco, and Richard C. Jordan, University of Minnesota; treasurer, Donald K. Tressler, recently appointed scientific director of the Quartermaster Food & Container Institute, Chicago.

The **American Society of Naturalists** has elected the following officers for 1951: Paul C. Mangelsdorf, of Harvard, president; B. P. Kaufmann, Carnegie Institution, vice president; Donald F. Poulson, of Yale, treasurer. Bentley Glass will continue as secretary for 1951–52. The society has recently assumed editorial control of *The American Naturalist,* and a subscription to that journal is included in the dues at a special reduced rate.

Thomas H. Chilton, technical director of the development engineering division of E. I. duPont deNemours & Co., was elected president of the **American Institute of Chemical Engineers** at its 43rd annual meeting in Columbus. William I. Burt, B. F. Goodrich Chemical Co. was elected vice president; and Stephen L. Tyler and C. R. DeLong, both of New York, were re-elected secretary and treasurer, respectively.

A symposium on **Metabolic Disturbances during Surgical Care** will be held January 12, at 10 A.M., in Wilson Hall, the Administration Building, National Institutes of Health, Bethesda, Md. Sponsored by the Surgery Study Section, under the chairmanship of Frederick A. Coller, of the University of Michigan, the symposium will include leading U. S. investigators in the field of experimental surgery. Visitors are invited to attend and participate in the discussion.

NRC News

A new **Food Protection Committee** has been established in the Food and Nutrition Board of the National Research Council. J. L. St. John, chairman of the Department of Agricultural Chemistry, State College of Washington, is on leave to serve as executive secretary, with offices at the council. The new committee will be concerned with correlating research and information on problems of food safety arising from the use of chemicals in growing crops, processing of food, and packaging and preservation of food. H. E. Longenecker, dean of the graduate school, University of Pittsburgh, is chairman. Other members are: W. J. Darby, Vanderbilt University Medical School; George C. Decker, Illinois State Natural History Survey Division; Donald E. H. Frear, Pennsylvania State College; C. E. F. Guterman, New York State Agricultural Experiment Station; Elliott A. Maynard, University of Rochester; L. A. Maynard, Cornell University; George L. McNew, Boyce-Thompson Institute for Plant Research; R. B. Smith, Jr., Medical College of Virginia; and Dr. St. John. To aid the new committee, an eleven-man industrial advisory committee has been appointed to represent chemical companies, food processors, drug manufacturers, and meat packers. In addition four subcommittees, on pesticides, toxicology, food technology, and chemistry, have been formed.

The proceedings of the **Conference on Primary Scientific Publica-**

tion, held last February under the auspices of the NRC, are available without charge from the chairman's office. The two-day conference, convened to discuss the problem of improving the publication and utilization of the results of scientific research, was attended by officers of technical societies, scientific journals, printers and publishers, industrial laboratories, and government agencies supporting research. Discussion was recorded on such topics as the responsibilities of investigators, educators, and sponsors of research toward publication; the needs of journals for financial assistance; cooperation between research institutions and journals to reduce publication costs; and government policy toward support of primary publication as a result of the large numbers of scientific papers now originating in government laboratories. The possibilities of reducing publishing costs by cooperative editorial and business arrangements, by ownership of printing facilities, and by the use of alternatives to letterpress printing were examined; increased income through advertising or by page charge assessments against authors or sponsors was also discussed. Finally, the conference considered the relation between research journals and other forms of publication such as government reports and house organs, and the question of defining primary publication.

Deaths

Nils Gustaf Hörner, of the Geological Institution, Uppsala, Sweden, died November 21 at the age of 54. An authority on Quaternary geology and geomorphology, he had made several trips to Asia, being geologist with Sven Hedin from 1929 to 1933.

Lawrence Paul Wehrle, 63, associate professor of entomology and associate entomologist in the Agricultural Experiment Station of the University of Arizona, died in Tucson October 23 of a heart attack. Dr. Wehrle had been in the department for 20 years and was interested primarily in the study of scales and aphids.

Eugene Gardner, co-discoverer of the meson, died November 26 of beryllium poisoning incurred during work on the wartime atomic bomb project. Dr. Gardner, who was 37, had been seriously ill since 1945.

Carol Gray Montgomery, of the Physics Department of Yale, and a specialist on cosmic rays, died December 3 of a heart attack. He was 41. During World War II he worked at MIT's radiation laboratory and also was active in the development of radar.

Clifton A. Woodrum, president of the American Plant Food Council, and a member of Congress from Virginia for 23 years, died October 6. He was 63.

Miscellaneous

The directors of **Central Scientific Company** have elected Harris M. Sullivan vice president and director of research and development. Dr. Sullivan has been with Cenco since 1944 as assistant director of research.

Paul J. Ernst, Physics Department, Temple University, Philadelphia, won first prize in the black-and-white division of the **Fourth Annual International Photography-in-Science Salon** for his print "Ultrasonograph of Pseudo-Standing Waves in front of an Ultrasonic Lens." First prize winner in the color division was Leonard F. Belanger, of the University of Ottawa, for his print "P-32 Radioautograph of a Growing Tooth."

Other winners in the black-and-white division were: Second prize, James B. Saunders, National Bureau of Standards, for his print "Precise Topography of Optical Surfaces;" third prize, J. A. Van Allen, J. J. Hopfield, and H. E. Clearman, Applied Physics Laboratory, The Johns Hopkins University, Silver Spring, Md., for their print "Ultraviolet Solar Spectrum from V-2 Rocket;" honorable mention, T. Brzeski, Polish University College, London; F. M. Cain and J. O. Mack, Carnegie-Illinois Steel Corporation Research Laboratories, Pittsburgh, Pa.; Philip O. Gravelle, The Gravelle Laboratory, South Orange, N. J.; K. Grube, L. W. Eastwood, and N. E. Winchester, Battelle Memorial Institute, Columbus, Ohio; and J. J. Hopfield, Applied Physics Laboratory, The Johns Hopkins University.

In the color division, the following also won awards: Honorable mention, Cecelia Mezowicz Ronai, General Foods Corporation Central Laboratories, Hoboken, N. J.; and Francis L. Shubert, Battelle Memorial Institute.

Judges in this unique competition for scientists and photographers, sponsored by THE SCIENTIFIC MONTHLY and the Smithsonian Institution, were A. Aubrey Bodine, of the Baltimore Sunday *Sun* (for photography); Walter F. Jeffers, of the Department of Botany, University of Maryland (for the natural sciences); Howard A. Meyerhoff, administrative secretary, AAAS (for metallurgy and the earth sciences); Merle Tuve, director, Department of Terrestrial Magnetism, Carnegie Institution (for the physical sciences); and Ralph W. G. Wyckoff, scientist director of the National Institutes of Health (for the medical sciences).

The prints will be on exhibition at the Annual Meeting of the AAAS in Cleveland, Ohio, December 26–30, and at the U. S. National Museum, January 3–31, after which they will go on tour of important scientific institutions in this country.

January Meetings

American Institute of Electrical Engineers (Winter). Hotel Statler, New York. Jan. 22–26.

American Library Association (Midwinter). Edgewater Beach Hotel, Chicago. Jan. 20–Feb. 3.

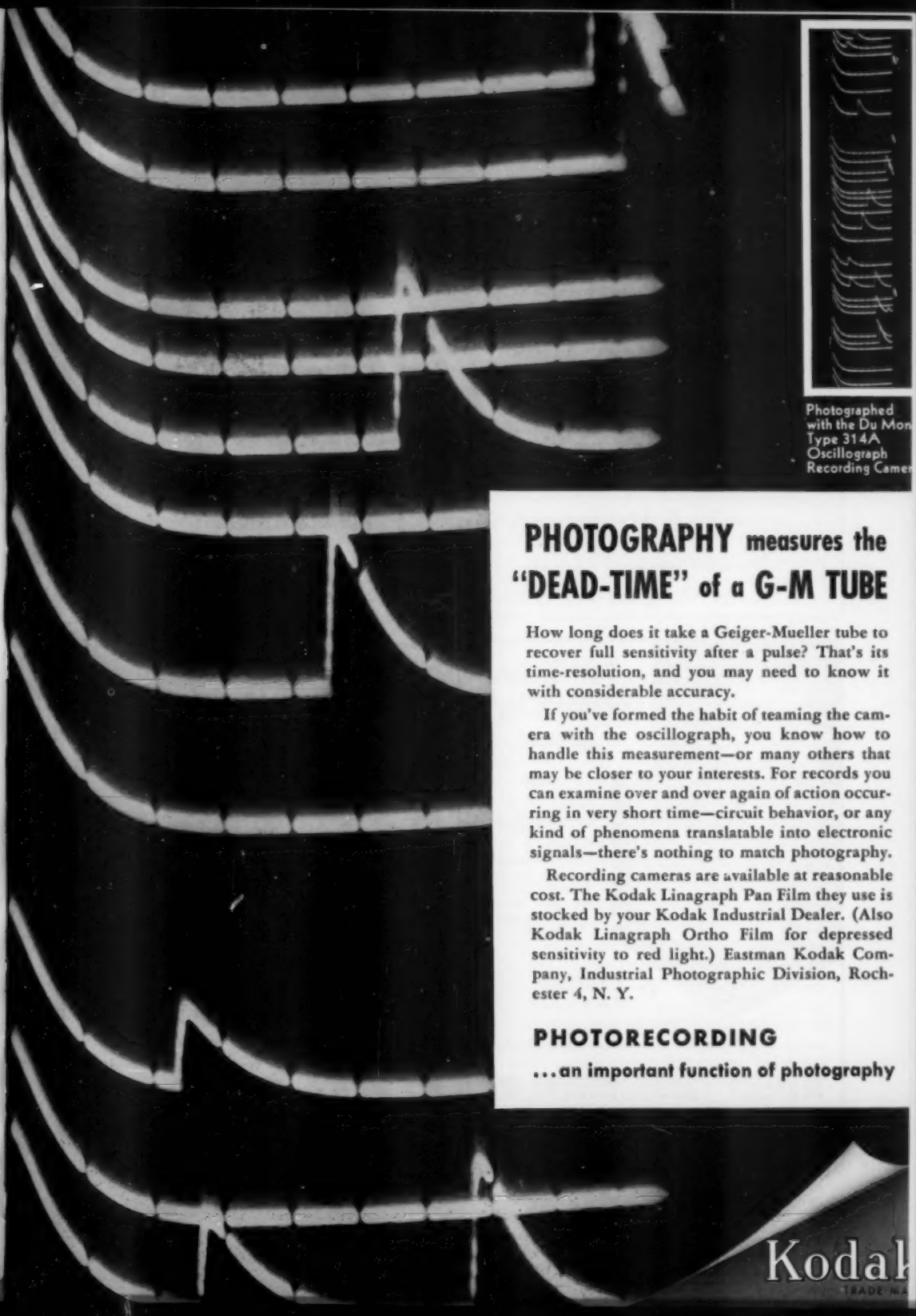
American Society for Surgery of the Hand. Palmer House, Chicago. Jan. 26.

Highway Research Board (Annual). Washington, D. C. Jan. 9–12.

Institute of the Aeronautical Sciences (Annual). Astor Hotel, New York. Jan. 29–Feb. 1.

Society of Automotive Engineers (Annual). Hotel Book-Cadillac, Detroit. Jan. 8–12.

World Power Conference. New Delhi, India. Jan. 10–15.



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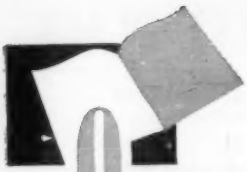

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Science Writer; Ph.D., Biochemistry; six years, associate editor of one of the scientific journals; for further information, please write Science Division, Medical Bureau (Burneice Larson, Director), Palmolive Building, Chicago. X

YOUR ad here will get RESULTS

POSITIONS OPEN

Biologist: Ph.D. Young man as collaborator on research project, screening antitumor agents. Box 374, SCIENCE. X

DALHOUSIE UNIVERSITY
Assistant Professor of Anatomy, Medical Faculty.
Salary $3,000 to $4,000 depending on qualifications. Apply to H. G. Grant, M.D., Dean, The Faculty of Medicine, Dalhousie University, Halifax, Nova Scotia, Canada.

Laboratory Assistant—Young woman with botany major to do fiber analysis, slide preparation, staining, sectioning, etc. in fiber microscopy laboratory. Send complete resume of personal and technical background. The Institute of Paper Chemistry, Appleton, Wisconsin. 12/15

Positions Open:
(a) Research associate; young physician required; duties entail taking care of clinical routine requirements of cardiovascular patients, assisting in experimental research work, conducted by cardiovascular unit; university medical school. **(b) Biochemist,** Ph.D., to supervise department of chemistry, two hospitals, combined capacity about 700; college town of 125,000, East; around $7000. **(c) Physiologist and biophysicist,** supervisory appointments; should be qualified to direct research programs involving effects of radiation on endocrines; Ph.D.'s required; medical degrees advantageous; West. **(d) Bacteriologist;** to join faculty, biology department, liberal arts college; large university, Ph.D. required; February. **(e) Director** of clinical investigation; key appointment carrying membership, executive committee; physician with M.S. or Ph.D. degree desirable; slight preference for internist. S12-3 Science Division, Medical Bureau (Burneice Larson, Director), Palmolive Building, Chicago. X

The MARKET PLACE

CHARGES and REQUIREMENTS for "MARKET PLACE" Ads

1. **Rate:** 20¢ per word for ***classified*** ads, minimum charge $5.00 for each insertion. Such ads are set in uniform style, without display; the first word, only, in bold face type.
For ***display*** ads, using type larger or of a different style than the uniform classified settings, and entirely enclosed with separate rules, rates are as follows:

Single insertion	$17.50 per inch
7 times in 1 year	16.00 per inch
13 times in 1 year	14.00 per inch
26 times in 1 year	12.50 per inch
52 times in 1 year	11.00 per inch

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3. **Closing Date:** Classified advertisements must be received by SCIENCE, 1515 Massachusetts Avenue, N.W., Washington 5, D. C., together with advance remittance, positively not later than 14 days preceding date of publication (Friday of every week).

For proof service on display ads complete "copy" instructions must reach the publication offices of SCIENCE, 1515 Massachusetts Avenue, N.W., Washington 5, D. C., not later than 4 weeks preceding date of publication.

BOOKS

Send us your Lists of
SCIENTIFIC BOOKS AND PERIODICALS
which you have for sale.
Complete libraries; sets and runs; and single titles are wanted.
Also please send us your want lists.
STECHERT-HAFNER, INC., 31 East 10th Street, New York 3 tf

PHYTOPATHOLOGY VOLUMES nine through forty, unbound, for sale. Make offer. Box 375, SCIENCE. X

WANTED — YOUR PERIODICALS
We need Complete Sets, Runs, Volumes and Single numbers.
CASH IN on your periodical accumulations NOW!
COLLEGE LIBRARY SERVICE • Dept. A, Box 311, N. Y. 3
Also send us your list of wants

WANTED TO PURCHASE:
SCIENTIFIC PERIODICALS
Sets and runs, foreign and domestic
SCIENTIFIC BOOKS
Entire libraries and smaller collections
WALTER J. JOHNSON
125 East 23rd Street, New York 10, N. Y.

Your sets and files of scientific journals are needed by our library and institutional customers. Please send us lists and description of periodical files you are willing to sell at high market prices. J. S. CANNER AND COMPANY, 909 Boylston Street, Boston 15, Massachusetts. tf

PROFESSIONAL SERVICES

ELECTRONIC RESEARCH—Equipment designed or built to specifications. Inventors, experimenters inquiries solicited. E. A. K. RESEARCH LABORATORIES, Dept. N, Tarrytown, New York. 12/15

TRANSLATIONS of French and German scientific books or articles, ½¢ per word. Box 376, SCIENCE. R1/12

• FOR SALE
see opposite page

The MARKET PLACE

SUPPLIES AND EQUIPMENT

GBI

For NUTRITIONAL RESEARCH

Write for GBI catalog No. 677 listing products for biochemical, biological, and microbiological procedures.

GENERAL BIOCHEMICALS, INC.

72 LABORATORY PARK CHAGRIN FALLS, OHIO

• HYPOPHYSECTOMIZED RATS

Shipped to all points via Air Express
For further information write

HORMONE ASSAY LABORATORIES, Inc. • 808 E. 58th St. Chicago 37, Ill.

WHITE RATS 40c and up

Rabbits, Cavies, White Mice, Ducks, Pigeons, Hamsters

Write • J. E. STOCKER • Ramsey, N. J.

All Amino Acids (natural, synthetic, unnatural), Rare Sugars, Biochemical Products, Reagents, New Pharmaceuticals in stock. Write or phone PLaza 7-8171 for complete price list

BIOS LABORATORIES, INC. 17 West 60th Street, New York 23, N. Y.

PARASITOLOGICAL PREPARATIONS

• high quality — low priced. *Write for catalog*

TROPICAL BIOLOGICALS • P.O. Box 2227, San Juan, Puerto Rico.

STAINS

STARKMAN Biological Laboratory

• RARE
• COMMON
Price list on Request
• 461 Bloor St., W. Toronto, Canada

"Your animal is half the experiment"

SWISS ALBINO MICE

ALBINO - W RATS

albino farms • P. O. BOX 331 RED BANK, N. J.

The MARKET PLACE

SUPPLIES AND EQUIPMENT

QUARTZWARE

for laboratory and industry

A complete line of standard laboratory ware. Also custom fabricating to meet your requirements.

For particulars, write: *Quartzware Division*

THE PANRAY CORP.

340 Canal Street, New York 13, N. Y.

INDEX of REFRACTION LIQUIDS

- Valuable Aid for Identification of Minerals and other Solids by the Immersion Method of Microscopy
- Range 1.400-1.700, intervals of 0.002, or as selected Index Certified to ± 0.0002
- Range 1.71-1.83, intervals of 0.01

Write for Price List Nd-S

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SPRAGUE-DAWLEY, INC.

Pioneers in development of the standard laboratory rat

Box 2071 • Madison 5, Wisconsin • Phone 36134

GLYCOCYAMINE—Hydroxyproline, L-Methionine

• AMINO ACIDS • BIOCHEMICALS
• PRE-MIXED MICROBIOLOGICAL ASSAY MEDIA

H. M. CHEMICAL COMPANY, LTD.

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LABORATORY ANIMALS

DOGS RATS RABBITS
CATS PIGEONS HAMSTERS
MICE POULTRY GUINEA PIGS

• Clean healthy well-fed animals
• Guaranteed suitable for your needs.

Reasonably priced—Dependable service

JOHN C. LANDIS • Hagerstown, Md.

ANIMAL CAGES AND ACCESSORY EQUIPMENT

BUY DIRECT FROM MANUFACTURER

HOELTGE BROS., Inc.

1919 Gest St. Cincinnati 4, Ohio

Write for 1950 Catalog

YOU can reach over → **32,000** **foremost scientists at a very low cost . . . by advertising in these columns**

If you have a product or service of interest to scientists, send your advertising copy NOW. You'll increase your Market, Sales, AND PROFITS at a very low cost.

HOTEL RESERVATIONS

117th AAAS MEETING

Cleveland, December 26-30, 1950

The list of hotels and the reservation coupon below are for your convenience in making your hotel room reservation in Cleveland. Please send your application, *not* to any hotel directly, but to the Housing Bureau of the Cleveland Convention and Visitors' Bureau to avoid delay and confusion. The experienced Housing Bureau will make assignments promptly and the hotel will send a confirmation directly to you in two weeks or less. **Please plan to share a room with a colleague.** In addition to economy, this will insure ample accommodations for all in the *downtown* hotels. Mail your application *now* to secure your first choice of desired accommodations.

HOTELS AND RATES PER DAY

Hotel*	Single	Double	Twin-Bedded	Suites
STATLER	$4.00–$8.00	$7.00–$10.00	$8.50–$12.50	$17.00–$23.00
HOLLENDEN	$3.50–$8.00	$5.50–$10.00	$7.00–$12.00	$12.00–$22.00
CARTER	$4.00–$6.50	$6.00–$10.00	$7.00–$10.00	$18.00–$25.00
ALLERTON	$3.50–$7.00 $2.50 RW	$6.00–$ 9.00	$6.00–$10.00 $4.00 RW	$10.00–$20.00
AUDITORIUM	$3.50–$5.00	$5.50–$ 7.50	$7.50	$12.50–$26.00
OLMSTED	$3.00–$6.00	$5.00–$ 9.50	$7.00–$ 9.50	$10.00–$15.00

Prices are subject to change, but are not likely to do so.
RW means running water only—no private bath.

* A list of the headquarters of each society and section is under **Association Affairs**, SCIENCE, August 25 and in THE SCIENTIFIC MONTHLY for September.

THIS IS YOUR HOTEL RESERVATION COUPON

Mrs. Louise D. Perkins, Director
Housing Bureau
Cleveland Convention and Visitors' Bureau, Inc.
511 Terminal Tower
Cleveland 13, Ohio

Date of Application .....

Please reserve the following accommodations for the 117th Annual Meeting of the AAAS:

TYPE OF ACCOMMODATION DESIRED

Twin-Bedded..... Rate.....
Suite..... Rate..... Number in Party.....
Double Room..... Rate.....
Single Room..... Rate..... Sharing this room will be:
.....persons.....
(Enumerate and attach list giving name and address of each person, including yourself)

CHOICE OF HOTEL

First Choice..... Second Choice..... Third Choice.....

DATE OF ARRIVAL..... DEPARTURE DATE.....
(These *must* be indicated)

SIGNED.....
(Please print or type)

ADDRESS.....
(Street) **(City and Zone)** **(State)**

Mail this now to the Housing Bureau.

Rooms will be assigned and confirmed in order of receipt of reservation.
Hotels will confirm directly in two weeks or less.

NEW α, β, AND γ *Proportional Counter*

SELECTIVE α, β, AND γ COUNTING • 2 π GEOMETRY • NO WINDOW ABSORPTION • AUTOMATIC PREFLUSH • NO "TUBE AGING" • NEGLIGIBLE COINCIDENCE LOSS • COUNTING RATE LIMITED ONLY BY SCALER • NO SPURIOUS PULSES • LOW BACKGROUND • ADAPTABLE TO GEIGER AS WELL AS PROPORTIONAL COUNTING

The Tracerlab Windowless Flow Counter and Pulse Amplifier together constitute one of the simplest, fastest, and most reliable proportional counters for use with commercial scalers. The Windowless Flow Counter may also be used separately for high efficiency Geiger counting of weak beta emitters or very low specific activity radioisotopes.

The absence of spurious pulses and negligible coincidence loss even at very high counting rates, which are inherent advantages of counting in the proportional region, combine with the absence of window absorption, the highly reliable pulse amplification, and the low background of this counter to make this unit one of the most useful in the field of radioactivity measurement.

For further details write for Bulletin S-29

Tracerlab

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2295 San Pablo Ave., Berkeley 2, California
New York Office
General Motors Bldg., 1775 B'way, N. Y. 19
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TRACERLAB INC., 130 HIGH STREET, BOSTON 10, MASS.

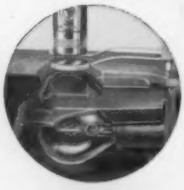
New Improved

SPENCER SCHOLAR'S MICROSCOPE

BETTER 4 WAYS FOR TEACHING

Stage Temperature Favors Most Living Material

New heat-absorbing glass and baffle plate prevent overheating.



Saves Time Teaching Science

So easy to learn and to use...more time is free for teaching *Science*. Simple controls permit more rapid operation.

A Precision Scientific Instrument

Standard quality Spencer trademarked optics. Precise all-metal bearing surfaces.

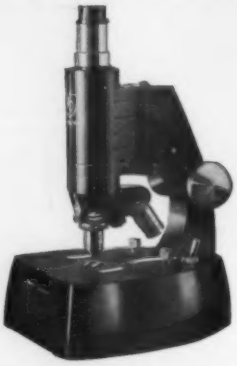
Low Cost to Buy and Maintain

Locked-in parts reduce maintenance costs-'Spring loaded' focusing mechanism protects slides.

PRICE

$109.00

(For 100X-430X model as illustrated)



● Spencer No. 78 Scholar's Microscope, with built-in factory-focused light source furnishes constant, uniform illumination and consequently better optical performance. Time-consuming and frequently faulty sub-stage adjustments are eliminated. Reversed position of microscope arm offers clear view of stage, objectives, and diaphragm openings. Low over-all height increases comfort. Time-saving single control provides rapid yet critical focusing. Ask your AO Distributor to show you the No. 78 Microscope... or write for catalog M153 to Dept. M3.

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